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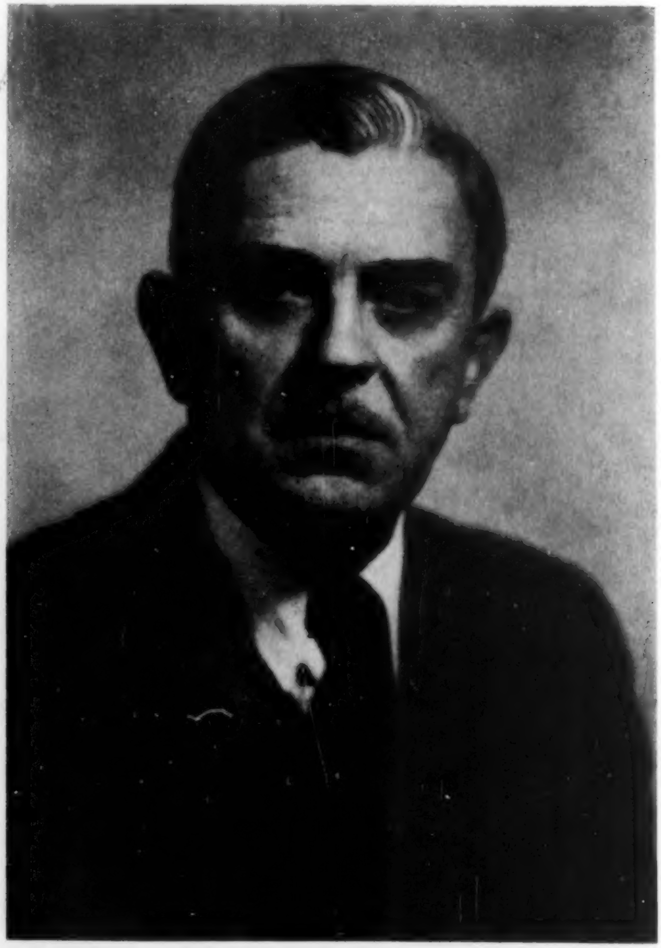

Charles John Pieper

VOLUME 41 MARCH, 1957 NUMBER 2

SCIENCE EDUCATION

THE OFFICIAL ORGAN OF

The National Association for Research in Science Teaching
The National Council on Elementary Science
Association on the Education of Teachers in Science

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SCIENCE EDUCATION

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CHARLES JOHN PIEPER

Charles John Pieper was born at Avilla, Indiana May 30, 1887, the fourth son of William and Rosina Vogeding Pieper. He married Josephine Marita Haley of Arcola, Illinois, April 2, 1929. (Deceased August 7, 1937). One son, Peter Joseph was born March 25, 1931. Peter served three and a half years in the Korean War, being discharged April 20, 1954. He is now employed in the New York City offices of Eastern Air Lines. Professor Pieper married Clare Elizabeth Gerry November 17, 1938.

Professor Pieper received an A.B. degree from Wabash College, Crawfordsville, Indiana, in 1910 and a Master's degree from Teachers College, Columbia University, in 1927. He did graduate work in science and education at the University of Chicago, University of Wisconsin, and Columbia University.

During World War I Professor Pieper served in the Signal Corps at Camp Grant and in the Chemical Warfare Services at headquarters in Washington, D. C. in 1918.

Teaching and administrative experience covering a period of 42 years includes: Rural Elementary School, Noble County, Indiana, 1905–6; Senior Laboratory Assistant in General Chemistry, Wabash College, 1909–10; Teacher of Chemistry, Shortridge High School, Indianapolis, Indiana, 1910–13; Teacher of Chemistry and General Science, University of Chicago High School 1913–15; Head of Department of Science and Supervisor of Student Teaching in Science, University of Minnesota High School, 1915–16; Head of Department of Science, University of Chicago High School and part-time instructor in Teaching of Science in the School of Education; also supervisor of student teachers of science and taught summer courses in the Teaching of Chemistry and General Science, 1916–18 and 1919–26; Assistant Professor of Education, New York University 1928–30; Associate Professor of Education 1930–32; and Professor of Education and Chairman of the Department of Science Education, New York University 1932–52. He was acting Chairman of the Department of Mathematics for eight years.

Publications include: *Laboratory Problems in General Science* (with Caldwell and Eikenberry), 1922; *Everyday Problems in General Science* (with Beauchamp), Scott Foresman and Company, 1925 and revised edition, 1932; *Everyday Problems in Biology* (with Beauchamp and Frank), Scott Foresman and Company, 1932; Teachers' Manuals to accompany the above texts and a series of tests to cover each unit of *Everyday Problems in Science* on (1) science information, (2) understanding of major ideas (3) growth in scientific method and scientific attitudes. (This was one of the early attempts to differentiate in teachers' and students' minds more specific objectives of science learning through evaluation procedures.) *Outlines in Natural Science*, 1924 (with Beauchamp and Frank), Pupil Guide Books of Activities for Unit Problems in Grades 7, 8, and 9, prepared for the new program of Junior High Schools in the Chicago Public Schools; Chapter on books and articles, *The Supervision of Natural Science*, Chapter II of Uhl and other *The Supervision of Secondary Subjects*, 1929; Science in the Seventh, Eighth, and Ninth Grades, Chap-

ter XIII of the Thirty-First Yearbook of the National Society for the Study of Education, *A Program for Teaching Science,* 1932; *Research Studies Relating to the Teaching of Science,* a series of bibliographies of research studies, *Science Education* October, December 1931, February, April 1932, April 1933, and April 1937; articles relating to supervised study in natural science, orientation science course for college students in the field of physical education and health, the functional organization of high school chemistry, objectives and methods in general science, and the administration of practice teaching have appeared in different sources.

Membership in organizations include National Association for Research in Science Teaching (Charter member and Life member), American Chemical Society, Central Association of Science and Mathematics Teachers, National Council for Elementary Science, Phi Delta Kappa, National Biology Teachers Association, National Science Teachers Association, American Nature Society, National Education Association, American School Administrators, National Society for the Study of Education, and the American Association for the Advancement of Science. He is a Fellow in AAAS. He is listed in *Who's Who in America, American Men of Science,* and *Leaders in Education.* Professor Pieper was a member of the Executive Committee of the National Association for Research in Science Teaching 1938–40 and served as Vice-President 1942–44.

Pieper's most challenging area of interest has been in the classroom at secondary, college, and graduate levels. The learner has been foremost in his mind and the clarification of objectives, the organization of course materials, the selection of learning activities, the direction of student learning and the evaluation of student growth have claimed most of his energy over the years. Over 6,500 students have been members of his classes at various levels. He has refused several offers of fellowships for graduate study in chemistry and offers of positions in chemical industry. He has not been a "joiner" and has shunned requests for work on committees, officerships in organizations, and other extra-classroom activities.

His interest in teaching was first inspired by his oldest brother, a teacher, principal, and superintendent of schools. The fourth graduate of the local rural high school to go to college, he was fortunate to have several outstanding instructors in science and education who encouraged his desire to teach. Later in teaching and in graduate work this interest was furthered through association and courses with Downing and Caldwell in science education, with Judd, Freeman, and Henmon in psychology, with Stieglitz and Koch in chemistry, and with Parker, Bobbitt, Elliot, Hanus, Jessup, and Morrison in various fields of education.

Pieper's interest in the learner, coupled with his belief in the views of physiological psychology rather than those of atomistic psychology regarding the nature of learning, and his development of a functional philosophy of education led him to many misgivings concerning the educational value of the content and teaching procedures in the then current secondary science courses. Extensive reading on the nature and meaning of science led to further doubts on the value of subject-centered "academic" science courses for general education.

The ultimate goals of science for general education came to be considered as growth in intellectual and overt human adjustment of the learner to the forces and materials of his internal and exterior environment through the study of everyday life problems. Learning was more than growth in memory of facts, giving of definitions, and "explanation" of principles in a ground-to-be-covered, organized science content. It was rather the joy and satisfaction in the recognition of real problems of everyday living and the concomitant growth in the spirit of discovery, the exercise of elements of creative and scientific thinking, and the em-

ployment of scientific attitudes necessary, at any grade level, in the solution of significant problems of human living in a democratic society.

This point of view led to the preparation of study materials for pupils of general science and chemistry, organized around problems of everyday life. After six years of trial and revision of mimeographed materials in general science classes, the "textbook" *Everyday Problems in Science,* by Pieper and Beauchamp, was published in 1925. The unit problems of the book were not subject-matter units of this or that academic science, as interpreted by Morrison and others, but were life problems of young persons.

The elaborate Teachers Guidebook (1927) attempted to implement the use of the new approach outlined in the texbook, by suggestions of objectives, activities, procedures, etc. Further elaboration of the philosophy and approach was presented by Pieper in Chapter XIII of the Thirty-first Yearbook, Part I, for grades 7, 8, and 9.

Pieper has often voiced his satisfaction in that he has had a part, through the early attempts at making science study more real to life, in the growth of this more functional view of science teaching which has gradually taken form in many schools.

For two years Pieper served as educational advisor in the formulation of a program of science at the junior high school level for the newly created Junior High School division of the Detroit, Michigan, Public Schools. In 1922 he offered one of the earliest courses of Orientation in Physical, Biological and Earth Science at the college level. in the School of Education, University of Chicago, based upon a problem approach.

From 1928 until his retirement in 1952 Pieper devoted his time to the development of the Department of Science Education, School of Education, New York University. He found here the opportunity to offer and direct orientation courses in physical and biological science at the college level for prospective elementary and secondary school teachers in accord with his philosophy of science teaching for general education. He also had an enlarged opportunity here to interest many prospective and in-service teachers of science in his views of a functional philosophy of science teaching.

The rapid growth of the department soon made it necessary for Pieper to delegate the teaching of the orientation courses and the courses in the teaching of science to other members of the staff, but the general philosophy and methodology of problem solving described earlier, has been promoted and expanded in the content and methods employed in the non-specialized science courses and in most of the professional courses for science teachers.

The expansion of course offerings in the department grew from a half dozen courses in 1928–29 to over 30 different courses in 1949–50. In this latter academic year the teaching schedule each semester called for (a) 40 class sections in orientation science for all undergraduates and special science courses for students in the department of home economics, physical education and health, industrial and vocational education, and elementary education, (b) 12 class sections in the teaching of elementary and secondary school science and in the supervision of student teachers, (c) 5 sections in graduate science for teachers of science, and (d) 6 sections of courses and seminars for master's and doctoral candidates.

The total offerings in semester hours of credit increased from 1,300 in the academic year 1928–29 to over 12,000 in 1949–50. Corresponding figures for the summer school rose from 250 in 1928 to 3,375 in 1950. The number of graduate students increased from a few dozen in 1928–29 to 224 each term in 1949–50. Of this total the registration for graduate degrees showed: M.A. 172, Ed.D. 13, and Ph.D. 39. Similarly the summer school registrations of graduates in the three summer sessions of 1950 totalled 268 divided as follows: M.A. 223, Ed.D. 18 and Ph.D. 27.

Growth in the instructional staff was also rapid. In 1928–29 the staff consisted of two full-time staff members, four part-time instructors, and five graduate assistants. By 1949–50 the staff included seven full-time members, 15 part-time instructors and 30 graduate demonstration and laboratory assistants. Those added to the regular staff, and well known in the field of science education included: Barnes, Robertson, Barnard, Winters, Lammel, Carmichael, and Adragna. The part-time staff were members of other departments in the School of Education, instructors in nearby colleges, and instructors of teachers colleges, and prominent teachers of science in New York City and other public school systems.

The growing number of students called for an increase in space and equipment. The science education staff was fortunate enough after some years of harried existence for space around the university to plan and equip one floor of the Education Building for departmental purposes. This included two large rooms especially designed for demonstration class activities and for discussion groups and other classes, a plant and animal room, a stock and preparation room for physical science, and a study-research library and a large foyer with numerous exhibit cases and storage cabinets. For additional space, laboratories and classrooms in other departments of the School of Education and Washington Square College were found.

As the department was enlarged, the advisement of students, course planning, instruction, custody and care of equipment and supplies, supervision of student teachers, sponsorship of research studies, etc. were delegated more and more to the regular staff members. Pieper, alone served as sponsor of 42 doctoral studies and a few masters' theses.

As chairman of a faculty committee, Pieper was largely responsible for the introduction in the School of Education of a Two-Year Program of Studies for freshman and sophomores who wished to prepare to teach English, social studies, science, mathematics, foreign languages, or speech in junior and senior high schools. The program provided opportunity for the student: (1) To extend his general education through orientation and cultural experiences in each of the following important fields of human endeavor: (a) the social studies, (b) language (English and general language), (c) the sciences (science and mathematics), (d) the arts, (e) personal living, and (f) sociology, (2) to explore the field of education as a social institution that provides for adolescents' experiences and guidance in school and community activities, (3) to explore his aptitude and abilities for teaching, (4) to begin his study in one or more of the special subject matter fields in accordance with his interests and aptitudes, and (5) to choose more wisely the teaching field or fields for which he desires to continue his preparation.

Following the successful completion of the two-year program of studies, the student, with the advice of his director, selected the particular academic teaching field or fields in which he was interested and matriculated in the appropriate special curriculum leading to the B.S. and A.M. degrees.

In 1929 Pieper was chosen chairman of the Editorial Board of the National Association for Research in Science Teaching and assumed the work of editor of *Science Education* which became the successor of *General Science Quarterly*, owned and published for thirteen years by W. G. Whitman. In 1931 the magazine was purchased by a group who incorporated the enterprise under the name *Science Education, Inc.*, with Pieper as president, Earl R. Glenn as vice president, and Clarence M. Pruitt as secretary-treasurer. Pieper continued as editor of the journal through November, 1943 with the assistance of Clarence M. Pruitt, the present editor and others. The Journal provided primarily a medium for promoting and reporting research studies,

for philosophical presentations, for bibliographies useful to science teachers, for editorials and news relating to science teaching, and for reviews of science texts, reference books and articles in other journals. From its inauguration *Science Education* has been the official organ of the NARST.

Under the capable and distinguished Editorship of Professor Pieper, *Science Education* attained the distinction of being one of the most outstanding publications in the educational field. In the area of research publications it was the foremost of all such magazines except one and it became recognized as the preeminent educational journal devoted to research in one academic teaching area. Very deliberately *Science Education* did not become the mouthpiece for any educational institution or for any educational group or clique, nor for any particular philosophy, psychology, or theory of education or of science education. For all of his many years of work on *Science Education* Professor Pieper never received a single cent of pay. All work was gratis. During his innumerable hours of work on *Science Education,* Professor Pieper could have been devoting his time and energy to tasks that would have assured him of more than adequate financial returns and/or other more tangible rewards. For this service, all science education workers, and to a large extent, education in general, owe Professor Pieper a debt of gratitude that can never be paid. We only hope that most of our readers appreciate the unselfish devotion to a task and to an ideal exemplified by Professor Pieper's really superb work on *Science Education.* Professor Pieper was ever the perfectionist. He was never satisfied with the least best if the best itself could be attained. He possessed the ability to patiently devote himself to the smallest detail in his editorial work.

The present Editor's task has been the easier because of the standards previously established. It is not always easy to follow the footsteps of the Master! Through some thirty years of association with Professor Pieper as a fellow-student in classes at Teachers College, as instructor on the staff, and as a co-worker on *Science Education,* we have grown to love and respect Charley as a keen, analytical thinker, as a warm, personal friend, and as a man of the highest personal and professional ideals.

In summary, it seems appropriate to emphasize the personal inspiration which people have received from association with Professor Pieper and the large number of doctoral studies he directed. His contributions to the New York University School of Education faculty were outstanding in at least three regards: (1) in planning of a general education program for all Freshmen in the School of Education (2) in the academic upgrading of graduate course requirements, and (3) in the less tangible but tremendously important pressure he exerted constantly in the direction of thorough, exhaustive study on any problem, big or little, and the insistence that whatever the undertaking it would be built upon a sound intellectual and practical foundation. Equally important are his writings, the furtherance of problem-solving techniques, and his work as Editor of *Science Education.* These contributions place Professor Pieper among the foremost science education leaders of this era. Personally we regret that his innate modesty has not permitted him a more aggressive leadership in science education and other educational organizations outside of New York University. We respect his attitude but we also believe science education could have been even much more enriched by his writing, thinking and organizational leadership.

It is an honor and a real personal pleasure to accord to Professor Charles John Pieper the Fifth Science Education Recognition Award.

CLARENCE M. PRUITT

AN EXAMINATION OF SCIENTIFIC METHOD AND ATTITUDE *

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ONE highly useful basis for evaluation of the degree of achievement of the objectives of a course of study of individual students is the achievement examination. It is the function of an achievement examination to express in terms of a single score a pupil's relative achievement in a given field. The single score then provides a basis for placing students in a rank order.

In order to achieve its purpose, as stated above, the examination should have certain characteristics and meet certain specifications. These include: test validity, reliability, item discriminating power, item difficulty and the distribution of item difficulties throughout the instrument, and, finally, the nature of the distribution of scores obtained from its use. Each of these characteristics will be defined and described with respect to an examination constructed to measure the attainment of the objective related to a knowledge of and ability to use the methods of science with an accompanying scientific attitude.

Many definitions of this objective have been stated, but for this examination the definition accepted is the ability to:

1. Select valid hypotheses to test in solving a suggested problem.
2. Identify the fixed, variable, and insignificant factors in an experimental situation.
3. Identify necessary though unstated assumptions in the solution of a problem.
4. Recognize a reasonable course of action to pursue in the solution of a problem.
5. Use satisfactory methods of recording data.
6. Recognize valid conclusions through proper interpretation of data. This involves keeping the conclusions within the data available by recognizing their incomplete nature and by interpolating and extrapolating within reasonable bounds.

The examination includes 27 multiple choice items and 36 statements involving interpretation of a mass of data and classifying each possible conclusion as true or false in the light of the data or not capable of being so classified because of insufficient data. The administration time is 55 minutes.

The examination was used with 121 students from 5 classes in chemistry. The classes included two from University of Minnesota high school and three from randomly selected schools of about the same size in the state of Minnesota. The range of scores on the 63 point test was 15–47, the mean score was 30.75 and the standard deviation was 7.66. The distribution was essentially normal as shown by plotting the raw scores against the cumulative percentage for each score on probability paper.[1] The straight line which was approximated indicated the desired normality of distribution. The intelligence quotients of the tested students ranged from 79–154 with a mean of 109.97 and a standard deviation of 15.34 as measured by the *Terman-McNemar Test of Mental Ability, Form C.*

To say that an examination has validity is to say that it measures what it is supposed to measure. This may mean several things. The validity of the test as a measure of the attainment of the objective was established, at least partially, by making certain that each question was directly related to one of the basic abilities or factors previously defined.

However, validity may refer to the ability of the individual items to measure the ability in question. In other words, an

* This paper is part of a thesis submitted to the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Doctor of Philosophy, 1950.

[1] As an example of such a determination of normality see Clarence H. Boeck, "The Inductive-Deductive Compared to the Deductive-Descriptive Approach to Laboratory Instruction in High School Chemistry," *Journal of Experimental Education,* 19:247–253, 1951.

item has validity when it can be expected that those who respond correctly to the item are more competent than those who fail it. This type of validity can be described by the term *discriminating power.* The extent to which an item has discriminating power was determined by checking each item to determine whether the percentage of those who answered correctly from among the best students, as measured by the total score on the test, was significantly greater than the percentage from the poorer students who also got the question correct.

The nomograph of Fattu [2] was used for determining the significance of the difference between the proportions of the lower and upper 27 per cent who scored each item correctly as a measure of item validity and discriminating power. A great deal of time was saved through the use of this nomograph which was constructed after the pattern set by Zubin,[3] for no calculations were necessary after the item counts and percentages had been determined.

The number of correct responses to each item was determined from all papers and the percentage of the possible number of correct responses was calculated. This percentage was used as a measure of the item difficulty.

The included Table 1 summarizes the results of this work. An indication of the distribution of item difficulty was made possible by dividing the items into three classes: easy, those passed by 75 per cent or more of the students; average, passed by 25–75 per cent of the students, and hard, passed by 25 per cent or less of the whole group. The table also shows the percentages of the upper and lower groups (27 per cent of the total group) who passed each item. Items where the significance of the difference of these proportions was not established at the 1 per cent or 5 per cent levels, are indicated by an N in the significance column. Items having significance at the 1 per cent level are indicated by 1 and those at the 5 per cent level by 5. Items with negative discrimination, those in which the lower group obtained more correct answers than the upper group, are indicated by —N.

Questions ranged in difficulty from 7–95 per cent with an average difficulty of 48.65 per cent. Easy questions were five in number, one was negatively discriminating and two were discriminating at the 5 per cent and one at the 1 per cent level of significance. Among the 48 average items were three which were negative in their discrimination, 10 with discrimination at the 5 per cent level and 30 with discrimination at the 1 per cent level of significance. Two of the hard items had negative discrimination and one was discriminating at the 5 per cent level of significance. The majority of questions were of average difficulty and thus most of the questions were operating to distinguish between a larger number of students than those which were either easy or hard. It is also interesting to note that no close relationship is apparent between item difficulty and discriminating power.

The reliability of the examination was estimated, using analysis of variance as described by Hoyt.[4] The coefficient of reliability determined by this technique gives the percentage of the variance in the distribution of test scores that may be regarded as true variance or variance not due to the unreliability of the test. The relia-

[2] N. Fattu, "Significance of the Differences between Proportions," Committee on Educational Research, University of Minnesota. 1939. Blueprinted.

———, "Interpretation of N. Fattu's Nomograph," Committee on Educational Research, University of Minnesota. 1946. Mimeographed.

[3] J. Zubin, "Nomographs for Determining the Significance of the Differences Between the Frequencies of Events in Two Series or Groups," *Journal of the American Statistical Association,* 34:539–544. 1939.

[4] Cyril Hoyt, "Test Reliability Estimated by Analysis of Variance," *Psychometrika,* 6:153–160, 1941.

bility coefficient was calculated to be .77.

In summary, it may be said that this examination:

1. Gave an average score about half the total possible score.
2. Had a preponderance of items of average difficulty.

TABLE 1

DIFFICULTY AND DISCRIMINATING POWER OF EXAMINATION ITEMS

Difficulty 75% and Above (Easy)

Item Number	% All Students	% Upper 27%	% Lower 27%	Significance
21	89	97	79	5
22	95	94	97	—N
24	88	91	85	N
25	75	91	64	5
50	78	91	55	1

Difficulty 25–75% (Average)

Item Number	% All Students	% Upper 27%	% Lower 27%	Significance
1	28	48	21	5
2	58	82	27	1
3	71	88	52	1
5	52	79	42	1
6	57	79	42	1
7	57	76	30	1
8	58	73	39	5
10	62	79	39	1
11	39	58	27	5
13	61	91	42	1
15	41	85	21	1
16	64	91	36	1
17	34	45	18	5
19	31	27	27	N
20	55	69	30	1
23	50	55	39	N
26	54	69	39	5
27	71	100	55	1
28	63	79	55	5
29	68	97	36	1
30	50	91	21	1
31	55	76	33	1
32	72	94	52	1
33	65	82	55	5
34	43	69	18	1
35	39	55	33	N
36	57	82	42	1
37	42	52	24	5
38	54	82	24	1
39	26	18	36	—N
40	40	73	15	1
41	32	21	48	—N
42	48	64	45	N
43	49	79	33	1
44	31	58	12	1
46	51	73	24	1
47	68	76	55	N
48	45	33	39	—N
51	47	69	39	5
53	59	91	21	1
54	42	48	15	5
55	63	88	30	1
56	73	91	45	1
57	50	69	18	1
58	49	76	21	1
60	41	61	9	1
62	58	88	30	1
63	36	64	6	1

Difficulty 25% and Below (Hard)

Item Number	% All Students	% Upper 27%	% Lower 27%	Significance
4	13	15	18	—N
9	7	6	6	N
12	22	24	24	N
14	24	27	18	N
18	21	21	15	N
45	18	24	6	5
49	23	24	15	N
52	18	3	33	-N
59	22	21	18	N
61	11	18	0	1

3. Contained a majority of items with good discriminating power.
4. Contained a few items with negative discriminating power.
5. Produced essentially normal distributions of scores for the groups tested.
6. Had reasonably good validity.
7. Had satisfactory reliability which might be improved by removal of the items with negative discriminating power.

CHEMISTRY EXAMINATION

Directions

The exercises which follow are of several types. Each type will have its own directions which you are to follow. In every case you will indicate your answer by placing an X through the number of the appropriate response on the answer sheet. Indicate all answers on the answer sheet. *DO NOT WRITE ON THIS TEST.*

Section I

1. An insecticide is suspected of containing an arsenic compound. The Marsh Test which is used for checking this suspicion requires that hydrogen be supplied. It is customary to produce the necessary hydrogen by the action of sulfuric acid on zinc. If we find arsenic to be present, which one of the following assumptions must be fulfilled in order to accept the evidence of the test? Cross out the number of your choice.
   (1) Hydrogen must be produced by the action of sulfuric acid and zinc; (2) the zinc and sulfuric acid contain no arsenic; (3) hydrogen is a reducing agent; (4) arsine, a compound of arsenic and hydrogen, is produced during the test.

2. One of the major cigaret makers has a secret device which it is claimed will remove chicken feathers from tobacco electrically. Brand XXX plans to use this in an advertising campaign. Cross out the number of the one assumption which follows, which must be accepted in order that such advertising material be an influence toward buying Brand XXX.
   (1) Chicken feathers can be removed from tobacco electrically; (2) Feathers can be given a static electric charge; (3) The quantity of chicken feathers in all cigaret tobaccos is great enough to cause poor taste quality in cigaret smoke; (4) If chicken feathers are present in cigaret tobacco, the quantity is very small and requires removal by electrical means.

Section II

In the two questions which follow, A and B, an experiment will be described. Following the description will be a series of experimental factors. Read the description and then classify each factor as (1) if the factor should be fixed or held constant, (2) if the factor is to be varied, (3) if the factor is of little importance, (4) if the factor is not at all related to the experiment. Cross out on your answer sheet the number which expresses your opinion about each factor.

A. *Purpose:* To discover the effect of the addition of various negative ions to a solution of known acidity. The method to be used is to add an indicator to the solution and then add the salts to separate samples. Changes in acidity will be indicated by changes in the color of the solution.

Factors:

3. The concentration of the original solution
4. The acidity of the indicator to be used
5. The kind of negative ion added
6. The quantity of salt added
7. The quantity of indicator added
8. The kind of positive ion added
9. The depth and diameter of the container in which the test is to be made
10. The acidity of the original solution.

B. *Purpose:* To determine the relative solubility of iodine in carbon tetrachloride and benzene by the process of extraction of iodine from a water solution. The method to be used is to shake the water solution with a quantity of the second solvent and subsequent removal of the second solvent. The process is to be repeated with the water solution until no color remains in the water layer. The number of extractions required will be used as an indication of solubility.

Factors:

11. The solubility of sodium iodide in water
12. The nature of the solvent
13. The temperature of the solvents
14. The pressure on the mixtures
15. The amount and vigor of shaking
16. The quantity of solvent used in each extraction
17. The boiling points of the solvents
18. The color of the added solvent after extraction.

Section III

Cross out the number of the correct response on your answer sheet.

19. Which of the following experiments would give definite information as to whether zinc is present in a certain solution as Zn^{++} or $ZnO_2^{=}$ ions? (1) See whether the solution is positively or negatively charged. (2) Hold a glowing splint above the liquid. (3) See whether zinc will plate out on a piece of copper placed in the solution. (4) Add hydrogen sulfide and examine for a white precipitate of ZnS. (5) Add an acid and test for hydrogen.

20. The acidity or alkalinity of a solution is often designated by one of a series of numbers from 0 to 14. In the series, 7 is neutral while 0 is acid and 14 alkaline. A certain indicator paper shows different colors depending on the

degree of acidity or alkalinity. It is desired to determine, by using this paper, whether the acidity or alkalinity is nearer 3, 6, 9, or 12 but the key to the colors has been lost. Which of the following would be most useful in helping to arrive at an answer? (1) a description of the chemical nature of the material on the test paper. (2) Run an experiment to see how rapidly H_2 is liberated when the solutions react with zinc. (3) A set of solutions having acidities and alkalinities of 3, 6, 9, and 12. (4) A series of titrations with known concentrations of acid and base. (5) A full set of indicators such as phenolphthalein, methyl orange, and congo red.

Section IV

A gas is produced and passed into a solution of barium hydroxide. A white precipitate forms. It is concluded that the gas is carbon dioxide because CO_2 gives a white precipitate in $Ba(OH)_2$.

21. Cross out the statement you feel is most reasonable.
(1) The conclusion can be accepted as it stands. (2) There is no justification for the conclusion. (3) The conclusion can be accepted if it is assumed that only CO_2 forms a precipitate with $Ba(OH)_2$.

22. Cross out the number of the response which corresponds to the best means of checking the assumption in (3) above.
(1) Consult a table of ionization of salts. (2) Pass gases other than CO_2 through $Ba(OH)_2$ and note the results. (3) Ask your student friends for their opinions.

23. Now assume that you find that SO_2 gives the same results as CO_2 when passed into $Ba(OH)_2$ and that you know nothing more about these gases. Which experiment would you find most useful in deciding whether the unknown gas is SO_2 or CO_2? Cross out the number of the most useful experiment on your answer sheet. (1) Check to see if a burning splint is extinguished in the gas. (2) Check the solubility of the gases in H_2O. (3) Test water solutions of the gases with blue litmus paper and note any color changes. (4) Make SO_2 and CO_2 and pass each through separate samples of potassium permanganate and compare results with those obtained from the unknown gas. (5) Smell the gases.

Section V

A student performs an experiment in which each of several elements are treated as follows: a. heats the element in air; b. dissolves the product of the reaction in water; c. tests the water solutions with litmus paper. The student arranges his data in a table like this.

24. Which item of information in Column I, cross out 1, 2, 3, or 4 on your answer sheet, is inconsistent with the other three items in the column?

25. Which item in Column II could not have been obtained from this experiment alone? Cross out 1, 2, 3, or 4 on your answer sheet.

26. Which of the following should be filled in as a heading for Column II?
(1) Appearance of the reaction
(2) Color of oxide formed
(3) Appearance of the product

27. When the bell rang space IV could not be filled in because the experiment had not been completed. Which of these procedures should be followed?
(1) Look up the reaction in the book and fill in the correct answer.
(2) Reason that since an oxide of a metal was formed, the solution should turn litmus blue and then fill in the space with "blue."
(3) Leave the space blank and make arrangements to complete the experiment later.
(4) Put down the answer obtained by a classmate who finished the experiment.

Section VI

The following problems provide you with experimentally obtained data. The numbered statements following the data are to be evaluated only in terms of the data presented. Read each statement and cross out on your answer sheet (1) if the data makes the statement true, (2) if the conclusion is contrary to the data, false, (3) the data is insufficient for the conclusion.

A. Bromine liberates sulfur from hydrogen sulfide. Chlorine liberates bromine when added to sodium bromide solution. When bromine is added to a sodium iodide solution iodine is liberated.

28. Chlorine is more active than sulfur.
29. Fluorine is the most active non-metal.
30. Iodine is more active than sulfur.
31. Chlorine will replace iodine in sodium iodide.
32. Iodine is less active than bromine.

B. Water solutions of sulfur containing compounds are being tested for the presence of sulfide, sulfite, and sulfate ions. These tests involve the use of the following facts: $KMnO_4$ is bleached by sulfur dioxide, white barium sulfate is insoluble in HCl, lead sulfide is black and insoluble in water. To solution W was added lead acetate, a black precipitate resulted. $KMnO_4$ was added to another sample of W and was bleached colorless. No precipitate formed when HCl and $BaCl_2$ were added to a third sample.

Substance	I Flame Color	II	III Color of Litmus Paper
Na	(1) Yellow	(1) White solid	Blue
C	(2) Burns	(2) CO_2	Red
P	(3) White	(3) White smoke	Red
Cu	(4) Green	(4) Black solid	IV

33. Sulfide ions are present.
34. Sulfate is probably present.
35. Sulfite is present.
Solution Z produces no precipitate with lead acetate, the $KMnO_4$ is bleached.
36. Sulfide is present.
37. Sulfide and sulfate are proven absent.
38. Sulfite is present.

C. An experiment was designed which was expected to produce HBr and HI by the action of concentrated sulfuric acid on NaBr and NaI. Arrangements were made to pass some of each gas into containers of $AgNO_3$ where pale and bright yellow precipitates would indicate the presence of HBr and HI respectively. When the H_2SO_4 was added to the flask containing NaBr an orange colored gas resulted while in the flask containing NaI a purple color was seen. The $AgNO_3$ showed a very slight precipitate with the gas from NaBr but none from the gas from the NaI.

39. NaBr and NaI were reduced to bromine and iodine.
40. HBr and HI cannot be produced by double replacement reactions.
41. Bromides are poorer oxidizing agents than iodides.
42. More Br_2 and I_2 were produced than HBr and HI.
43. In connection with the preceding experiment the following hypothesis were suggested as to the reason for the results obtained. Indicate which hypothesis seems to be the one most reasonable to consider further.
    1. The concentration of the H_2SO_4 was too high to allow for sufficient ionization to free the number of H+ ions to form HBr and HI.
    2. The sodium compounds were too stable to liberate HI and HBr when in contact with H+ ions.
    3. There was insufficient water in the concentrated acid to cause the ionization of NaBr and NaI to take place.
    4. Concentrated sulfuric acid is a sufficiently good oxidizing agent to oxidize HBr and HI to I_2 and Br_2 as they are formed.
44. Which of the above hypothesis was partially confirmed when it was found that if H_3PO_4 in concentrated form was substituted for concentrated H_2SO_4, HBr gas could be produced?

Section VII

The situations of this section consist of sets of data on chemical and other problems followed by a series of statements which may or may not be supported by these data alone. You are to consider each statement and then cross out on your answer sheet (1) if the statement is true according to the data, (2) if the statement is false or contradicted by the data, or (3) if the data is not sufficient to determine whether the statement is true or false.

A. The following data were obtained from reputable scientific magazines.

7,257 city youngsters 12–14 years of ago who had drunk water containing fluorides all their lives needed only 1/3 as much dental work as those who drank water without fluorides.

Analysis of tooth enamel showed that undecayed teeth had a higher fluorine content than decayed teeth.

In six experiments in which a sodium fluoride solution was swabbed on the teeth of youngsters 2 to 15 times new decay in teeth was reduced 26 to 50 per cent.

In Oak Park, Illinois where drinking water contained no fluoride, there was 3 times as much tooth decay as in nearby Maywood, Illinois where drinking water contained 1 part per million of fluoride. It was assumed that since populations were similar diets would not likely be different.

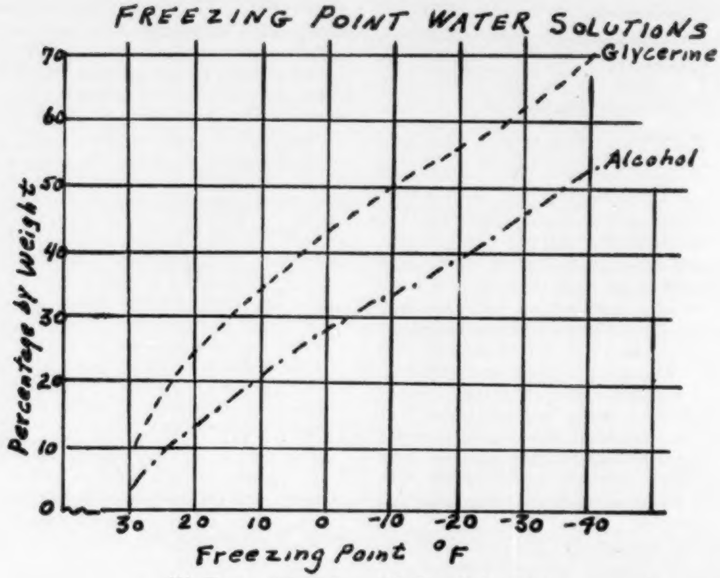
The cost of adding fluoride to water, about 15 pounds for one million gallons, is about seven and one-half cents per person per year.

Fluorine compounds are dangerously poisonous.

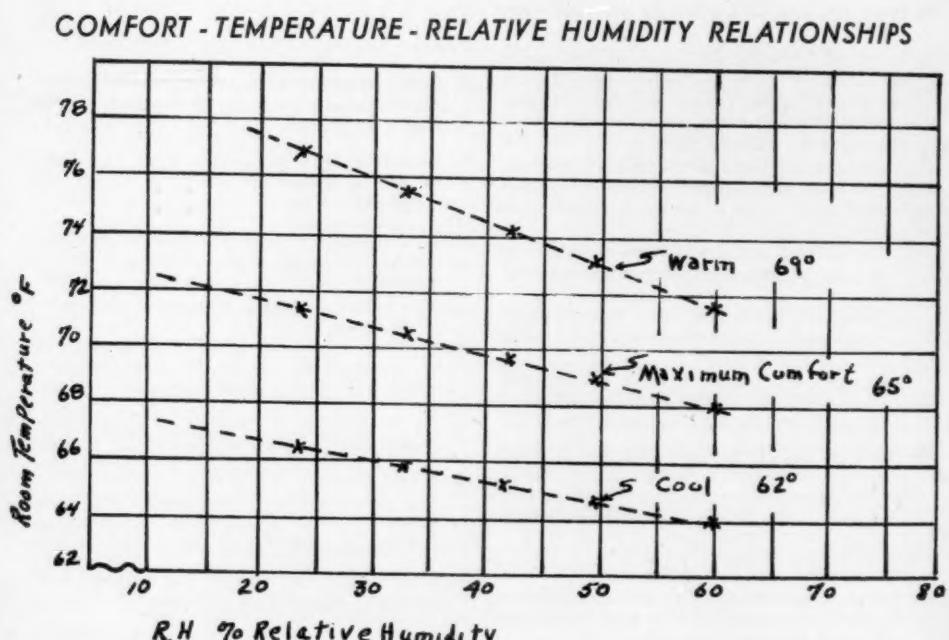
45. It has been conclusively proven that fluoride in water prevents tooth decay.
46. It is better to rub fluoride compounds on the teeth than to get the fluoride in drinking water.
47. Since fluoride intake does not completely eliminate tooth decay, some other factors must also be involved.
48. Experimentation shows that water containing as little as 1 part per million of fluoride reduces tooth decay in children by 1/3 to 1/2.
49. Toothpastes and powders should be compounded to include some sodium or potassium fluoride.

See Graph, next page

50. It requires nearly 20 per cent more glycerine by weight than alcohol to give the same radiator protection at 40° below zero F.
51. An increase in the amount of solute added brings about a depression of the freezing point.
52. The percentage of solute needed for lower freezing point protection increases at a greater rate for alcohol than for glycerine.
53. It is more economical to use alcohol as an antifreeze than to use glycerine.
54. Quart for quart, alcohol gives more protection against freezing than glycerine in the same automobile radiator.
55. It is safer to use alcohol than glycerine during periods when the day time temperatures may go well above freezing.



(1) True (2) False (3) Insufficient data.



Temperature Conditions: Still air, warm walls
Comfort Conditions: Persons normally clothed, slightly inactive
Warm—effective body temperature of 69° F.
Comfort—effective body temperature of 65° F.
Cool—effective body temperature of 62° F.

(1) True (2) False (3) Insufficient data.

56. For maximum comfort, the relative humidity should decrease as temperature increases.

57. No animal would be comfortable at 66° F. and R.H. 30 per cent.

58. No one would feel quite comfortable at 72° F. if R.H. were 17 per cent.

59. If one could properly control the R.H. of air at 80°, he could be just as comfortable as at 69° and R.H. 50 per cent.

60. These data prove that a closed room full of people would soon feel very warm due to an increase in R.H. due to perspiration.

61. One would expect to be more comfortable at R.H. 42 per cent if the temperature were 72° than if it read 67.3 per cent.

62. Air at 72.5° and R.H. 10 per cent is more comfortable than air at 71.5° and R.H. 60 per cent.

63. As the temperature drops, the R.H. for comfort must rise because body cooling depends on the rapidity of evaporation of perspiration.

THE WHOLE TRUTH AND NOTHING BUT THE TRUTH EXAMINATION

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INTRODUCTION

OBJECTIVE tests in science usually consist of items in which the examinee must choose one correct response from among several alternatives. By gaining facility in the elimination of unlikely alternatives, many students become "test-wise" and score higher than their comprehension of the science would warrant. Another reason for the traditional objective test in science contributing to high rating without adequate comprehension is the emphasis on the acquisition of factual information to the neglect of testing for critical thinking.[1] These shortcomings may be counteracted, to some extent, by the development of science tests measuring not only factual information, but application and interpretation as well; and the items of such a test might well be of such a nature as to defeat the "test-wise" student and place him where he belongs.

The purpose of this article is to present selected items from an examination of introductory high school chemistry that tested: (a) the acquisition of concepts and principles, (b) the application of principles, and (c) comprehension and interpretation. The items were couched in terms that required the examinee to select one, *or more than one,* response from several alternatives. Each item was considered correct only if *all* the correct responses were selected and *all* the incorrect ones were rejected. The writer has referred to this type as the Whole-Truth-And-Nothing-But-The-Truth (WTANBTT) examination.

THE CRITERION EXAMINATION IN AN EXPERIMENTAL STUDY OF LEARNING

This WTANBTT type of examination was used by the writer in an experimental study comparing a laboratory-centered with a textbook-centered approach to the learning of chemistry. The examination, developed during a year of pilot study prior to the running of the experiment, correlated 0.66 with an outside criterion, the *Anderson Chemistry Test,* and showed a reliability of 0.95. Statistical aspects and conclusions of the study have been presented in the *Journal of Experimental Education.*[2] A summary also appears in *Dissertation Abstracts.*[3] This article deals only

[1] Dunning, Gordon M., "Evaluation of Critical Thinking," *Science Education,* 38:191–211 (1954).

[2] *Journal of Experimental Education,* March 1954, 22:265–271.

[3] *Dissertation Abstracts,* Ann Arbor, Michigan, 14(1954):504–505.

with the construction of the criterion examination.

In September of 1951, a full year previous to the commencement of the experiment, the production of the criterion examination was begun. Preliminary drafts of items were tried with the 1951–52 chemistry class (not differentiated with respect to method of instruction), and items were retained or eliminated on the basis of item difficulty and discrimination. The examination was administered to all the chemistry students at Lord Selkirk School, the locale of the experiment, as well as to students at other high schools in Winnipeg, Canada. On the basis of the results of these administrations and the critical comments of other high school and university chemistry teachers, the examination was revised into its final form.

THE THREE PARTS OF THE EXAMINATION

Part I of the examination consisted of items requiring the simple recall of basic facts, concepts, and principles. A typical item was:

A fluid refers to
(a) a gas
(b) a solid
(c) a liquid
(d) a crystal

The correct response was (a, c). Both alternatives had to be chosen in order for the answer to be considered correct.

Part II consisted of items requiring the *application* of facts, concepts, and principles. A typical item was:

A gas measures 150 ml. at a temperature of —23° C.
Its volume at 23° C. would be:
(a) 300 ml.
(b) 300 mm.
(c) 177.6 ml.
(d) 177.6 mm.

This item called for the application of concepts involved in the abbreviation of appropriate units of volume as well as for the application of Charles's Law. It also called for application of concepts involved in the relationship between Centigrade and Absolute temperature scales.

Part III tested for comprehension and interpretation, and was based on experiments that had been performed at regular laboratory sessions in which all students took part. Items tested whether the student could comprehend and interpret the findings as reported in the observations and conclusions of a chemistry experiment. For example, in an experiment to study the relative rates of diffusion of hydrogen chloride gas and of ammonia gas, one item read:

The results would be impaired if the glass tubing were wet on the inside because
(a) diffusion does not take place through liquids
(b) ammonia gas is soluble in water
(c) hydrogen chloride gas is soluble in water
(d) NH_3 and HCl are repelled by water

The three parts of the examination were equally weighted insofar as points or marks were offered. It was considered that, because of the extra time required to read the experiment report and to interpret the items, each item in Part III should be weighted twice as heavily as an item from Part I and II. Accordingly, Part III contained half as many items as in each of the other parts, and each item was scored two points. There were no partial marks awarded for partially correct answers.

CONTENT COVERED BY THE EXAMINATION

The chemistry content covered by the examination included: (a) matter and energy, (b) elements, mixtures, and compounds, (c) oxygen, (d) hydrogen, (e) the gas laws, (f) water, (g) solutions and crystallization, (h) atomic theory and atomic structure, (i) molecules and valence, (j) molecular composition of gases, (k) carbon and its oxides, (l) theory of ionization, and (m) acids, bases, and salts.

THE EXAMINATION

The items of the examination were of a uniform nature in order to minimize confusion on the part of the students with respect to the mechanics of test construction. The type of item used was the mul-

tiple-response variety of the multiple-choice form. This type is a correct-answer item, not a best-answer item.

The instructions and sample item given the pupils were as follows:

Each item on this test will be considered correct only if you tell the WHOLE TRUTH AND NOTHING BUT THE TRUTH. Thus, if there are four choices, one of them, two, three, or all four may be correct; and you must choose all the correct ones and leave out all the incorrect ones.

Example: Three times five is more than
(a) 5
(b) 10
(c) 15
(d) 20

The correct response to record on your answer slip is (a, b). Wrong answers would be (a) alone or (b) alone. It would also be wrong to give (a, b, c) or (a, b, d) You must find ALL the right answers and leave out ALL the wrong answers.

PART I: RECALL OF FACTS, CONCEPTS, AND PRINCIPLES (Selected Items)

1. Centi means
   (a) 100 times
   (b) 1/100
   (c) 1000 times
   (d) 1/1000

2. When barium chloride solution is added to a solution of sulfuric acid, there is
   (a) a reaction
   (b) a precipitate
   (c) an explosion
   (d) nothing left

3. A liter is
   (a) a metric system unit
   (b) a measure of volume
   (c) equal to 1000 cubic centimeters
   (d) equal to 1000 milliliters

4. Crystalline substances
   (a) often contain water of crystallization
   (b) are amorphous
   (c) are plastic
   (d) are sometimes efflorescent

5. Manganese dioxide is
   (a) black
   (b) an oxide
   (c) MnO_2
   (d) a compound

6. Standard temperature is the same as
   (a) 0° C.
   (b) 32° F.
   (c) the freezing point of pure water
   (d) 273° A.

7. A binary compound
   (a) is made up of only two elements
   (b) always contains only two atoms
   (c) may be an acid
   (d) may be a base

8. A base
   (a) reacts with an acid to form a salt and water
   (b) is a hydroxide
   (c) has a bitter taste
   (d) yields negative hydroxyl ions in solution

9. The number of electrons needed to fill the L-orbit of an atom is
   (a) 2
   (b) 8
   (c) 18
   (d) 32

10. Chemicals in a dry cell include
    (a) sulfuric acid
    (b) hydrochloric acid
    (c) manganese dioxide
    (d) ammonium chloride

11. The water solution of an electrolyte contains equal numbers of
    (a) positive and negative ions
    (b) positive and negative charges
    (c) electrolytes and non-electrolytes
    (d) molecules and atoms

12. A hypothesis is
    (a) a scientific guess
    (b) a theory
    (c) a law
    (d) a factual observation

PART II: APPLICATION OF CONCEPTS AND PRINCIPLES (Selected Items)

13. A mixture of 45 ml. of hydrogen and 20 ml. of oxygen is ignited by an electric spark in a eudiometer tube. There is left
    (a) some oxygen
    (b) some hydrogen
    (c) 5 ml. of one of the original gases
    (d) 25 ml. of one of the original gases

14. In order to form an acid you would
    (a) add water to an acid anhydride
    (b) add water to a basic anhydride
    (c) add water to an oxide of a metal
    (d) add water to an oxide of a non-metal

15. A package of washing soda crystals (sodium carbonate) labeled "One Pound" was found to contain only 15 oz. Assuming the packer was honest, the discrepancy may have been due to
    (a) deliquescence
    (b) atomic disintegration
    (c) efflorescence
    (d) effervescence

16. A gas collected when the temperature is 33° C. and the pressure is 80 cm. measures

500 ml. The volume at —3° C. and 750 mm. is
(a) 500 x (306/270) x (800/750) ml.
(b) 500 x (270/306) x (800/750) ml.
(c) 500 x (306/270) x (750/800) ml.
(d) 500 x (270/306) x (750/800) ml.

17. Seven grams iron unite with 4 g. sulfur to form 11 g. ferrous sulfide. According to the law of definite proportions
(a) 4 g. iron should unite with 7 g. sulfur
(b) 21 g. iron should produce 33 g. ferrous sulfide
(c) 14 g. iron should unite with 8 g. sulfur
(d) 12 g. sulfur should produce 33 g. ferrous sulfide

18. If you wished to illustrate a chemical change, you would
(a) magnetize some steel
(b) burn some wood
(c) melt some ice
(d) explode some gunpowder

19. The equation, $H_2 + Cl_2 \longrightarrow 2\ HCl$, tells us
(a) one volume of hydrogen plus one volume of chlorine yield two volumes of hydrogen chloride
(b) one molecule of hydrogen plus one molecule of chlorine yield two molecules of hydrogen chloride
(c) one pound of hydrogen plus one pound of chlorine yield two pounds of hydrogen chloride
(d) one quart of hydrogen plus one quart of chlorine yield two quarts of hydrogen chloride

20. Sodium has an atomic weight of 23 and an atomic number of 11. One atom of sodium has in its outer shell
(a) 1 electron
(b) 3 electrons
(c) 2 electrons
(d) 7 electrons

21. The valence of ferric iron is +3 and of the nitrate radical is —1. The formula for ferric nitrate is
(a) $FeNO_3$
(b) Fe_3NO_3
(c) Fe_2NO_3
(d) $Fe(NO_3)_3$

22. Ten liters of a gas at S.T.P. weigh 25 grams. Its molecular weight is
(a) 2.5
(b) 250.0
(c) 156.0
(d) 56.0

23. Atomic weights: Ca = 40, C = 12, O = 16. A molecular weight in grams of $CaCO_3$ is heated and completely decomposed according to the equation, $CaCO_3 \longrightarrow CaO + CO_2$. The amount of carbon dioxide produced is
(a) 22.4 liters at S.T.P.
(b) 44 grams
(c) 44 grams at S.T.P.
(d) 44 grams at room temperature

24. When the reaction between sodium and water is expressed in a balanced equation, the number of hydroxyl radicals produced is
(a) 1
(b) 2
(c) 3
(d) 4

PART III: COMPREHENSION AND INTERPRETATION

(Selected Items)

EXPERIMENT I

Object: To determine the percentage of water of crystallization in crystalline copper sulfate (bluestone).

Apparatus: Balance and weights, crucible, tongs, triangle, stirring rod, burner, fine crystals of $CuSO_4 \cdot 5H_2O$.

Method: Weigh crucible. Place about three grams bluestone into crucible and weigh again. Heat crucible and stir contents until the resulting powder is a uniform white color. During the heating, hold a cold dry object over the crucible and look for droplets of water. After heating is complete, hold the crucible with tongs and tap the stirring rod gently so that all the white powder remains in the crucible. When cool, the crucible should be weighed again. Calculate the percentage of water lost.

Assumptions and Expectations: Each molecule of copper sulfate in crystalline form has attached to it five molecules of water. On being heated, the molecules of water separate from the copper sulfate, leaving it in the form of a white powder called anhydrous copper sulfate. The molecular weight of hydrated copper sulfate (bluestone, $CuSO_4 \cdot 5H_2O$) is (from atomic weight tables) 249.5. The relative weight of the water is 90. Therefore, the theoretical percentage of water in bluestone is (90/249.5) x 100 = 36.1 per cent.

Observations: Weight of crucible was 15.10 grams. Crucible + bluestone = 18.20 grams. Crucible + powder after heating = 17.08 grams. Weight of bluestone, 18.20 — 15.10 = 3.10 grams. Weight of powder, 17.08 — 15.10 = 1.98 grams. Weight of water expelled, 3.10 — 1.98 = 1.12 grams. Percentage of water in bluestone, (1.12/3.10 x 100 = 36.1 per cent.

Conclusion: The percentage of water of crystallization in crystalline copper sulfate is about 36 per cent.

25. We know that water was driven off because
(a) the bluestone lost weight on being heated
(b) the bluestone changed color
(c) water droplets formed on the cold object
(d) it would be unscientific to think otherwise

26. Factors that contributed to the experimental value turning out exactly the same as the theoretical value may have been
   (a) purity of the chemical used
   (b) skill in manipulation
   (c) rounding the values to one decimal
   (d) incorrect arithmetic

27. This experiment indicates that
   (a) the percentage of water of crystallization in bluestone is about 36 per cent
   (b) the percentage of water of crystallization in all hydrated salts is 36 per cent
   (c) bluestone loses its water of crystallization on being heated
   (d) all hydrated salts lose their water of crystallization on being heated

28. In view of the fact that the experimental value was exactly the same as the theoretical value
   (a) the experiment did not need verification
   (b) the *Conclusion* is wrong
   (c) the figures must have been "juggled" (falsified)
   (d) the experiment supported the fact that the formula for bluestone was $CuSO_4 \cdot 5H_2O$

29. If the experimental value had turned out to be 35.9,
   (a) the same conclusion could be used
   (b) all the water may not have been removed from the bluestone
   (c) the experiment would be considered a failure
   (d) no conclusion could be reached

30. If the resulting white powder were allowed to remain in the crucible, and enough water added until it was completely dissolved, then the solution set aside until it evaporated to complete dryness, the resulting crucible plus contents would weigh
   (a) 15.10 grams
   (b) 18.20 grams
   (c) 17.08 grams
   (d) more than 18.20 grams

KEY

PART I (One mark for each): 1 (b), 2 (a, b), 3 (a, b, c, d), 4 (a, d), 5 (a, b, c, d), 6 (a, b, c, d), 7 (a, c), 8 (a, b, c, d), 9 (b), 10 (c, d), 11 (b), 12 (a).

PART II (One mark for each): 13 (b, c), 14 (a, d), 15 (c), 16 (b), 17 (b, c, d), 18 (b, d), 19 (a, b, d), 20 (a), 21 (d), 22 (d), 23 (a, b, c, d), 24 (b).

PART III (Two marks for each): 25 (c), 26 (a, b, c), 27 (a, c), 28 (d), 29 (a, b), 30 (b).

TOTAL: 36 marks.

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DEVELOPING A SCIENCE PROGRAM FOR RAPID LEARNERS *

A. Harry Passow

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The impact of science and technology on our life and culture in the twentieth century needs no elaboration to science teachers. Almost nothing has remained untouched by the discoveries, inventions, research and creativity which have marked the past fifty years. If the achievements of the period since 1941 foretell anything, it seems likely that the next few decades will bring science revolutions which are staggering.

There is no question that science will go on playing a significant role in our lives—even, perhaps, determining our existence. There can be no question that we will need many scientists, not only to replenish the talent reservoir but to feed the ravenous manpower shortages which threaten us in the extended cold war. Our manpower needs intrude themselves daily and persistently. As specialization breeds more specialization, our requirements for trained scientific personnel increase geometrically. We stand now on the threshold of new discoveries; yet we may wonder soberly if creative, free scientists in sufficient numbers will be prepared to lead us knowingly into new eras.

It is a truism, of course, that the scientists of tomorrow are in our schools today. It is highly probable that these potential scientists are among our rapid learners—those students with high intelligence as measured by our standardized tests. Research by Brandwein, Haslett, Roe, and Wrenn points to high intelligence as one characteristic of the scientist. Wolfle's researches indicate that high intelligence marks individuals in the specialized talent areas. Intelligence alone, of course, does not make a scientist but we can be reasonably certain that as we develop science programs for rapid learners, we will be including most of our potential scientists.

What directions shall we take in developing science programs for rapid learners? In developing any program, one must heed several things: the characteristics of the learners, the nature of the discipline, the needs of society and the function of the school. Saying this another way: we have to be clear on the students for whom the program is intended, the goals of a program, the possible content and methodology, the levels at which it should be developed, and its relation to the total school program.

It seems to me that if we are to develop adequate science programs for rapid learners, we must attack the problems from new vantage points. Our past techniques have illustrated the old saying, pouring new wine into old bottles. That is, we have picked up existing sequences, materials, and methods and by modifying them, we have tried to increase or decrease the difficulty of a subject or the tempo of instruction. Certainly changes have been made and there has been some improvement but the paucity of good scientists and the general lack of public understanding of science are, in part, an indictment of existing programs. I would like to raise some of the issues and problems involved in developing programs and suggest some possible new directions.

SCIENCE PROGRAMS—FOR WHOM?

The development of the sciences and their influence on our culture make an understanding of the nature of science and its meaning to society essential for all rapid learners. This should not delude us into seeing a future scientist in every rapid

* Paper presented at the National Science Teachers Association meeting, March 15, 1956, Washington, D. C. Paper published with permission of NSTA.

learner. Realistically, some will become scientists, technicians, science teachers and engineers; others will not. However, all need science understandings and meanings which a program must provide.

As we look at those who will become scientists, we should remember how the nature of science itself has changed in the past few decades. Some of our previous large divisions have subdivided while at the same time several other areas of science have been synthesized. We have many different kinds of sciences and scientists. There will be youngsters who eventually will become research and pure scientists; others who will go into the applied sciences; and still others who will turn to science teaching. To what degree should the programs for these breeds of scientists be similar and at what points should they diverge?

Even the non-scientist who is to make a real contribution in his chosen area must, in a scientific world, absorb the meaning and the method of science. Problem solving is not confined to natural science pursuits alone; the method of science is equally applicable to other areas of learning. Terman's study of scientists and non-scientists found real differences in the interests, abilities, and social behavior of the two groups. Yet if we are to progress, the scientist and the non-scientist must understand each other and the world of science. Such understanding can come from adequate science programs which are appropriate for different kinds of rapid learners.

WHAT ARE SOME GOALS?

Adequate science programs will have varied purposes. For all rapid learners, whether potential producers or consumers of science, the program should result in basic understandings and meanings which constitute science in general education. The emphasis should be on ideas, concepts and relationships and not on information alone. The program should stimulate intellectual attainment and scholarship for all. It should develop inquiring minds, ignite curiosity and reward constant seeking of responses to the question "Why?" It should provide students with problem solving experiences and an understanding of the processes involved. The program should stimulate a desire for learning, seeking and studying. It should develop understandings of the relationship of science and the scientific method to other aspects of our culture. It should deepen students' understandings of the knowledge we have and the sources for extending that knowledge. These things the science program should do for all rapid learners.

In addition, the science program should provide the special skills, knowledge, and attitudes needed by those students who are potential scientists. It should develop interests and motivate rapid learners into seeking the means for developing their science potential. Specialization which differentiates the pure scientist from the applied scientist probably should not come until college. The basic program in secondary school should be essentially the same. For students who have the interest, critical judgment, creative ability, motivation and other characteristics which in combination with high intelligence make them potential scientists, the program should serve both to recruit and educate. For these rapid learners, the science program must serve both general and special education function.

Objectives like these—and many science teachers can develop better and more comprehensive lists—emphasize the unique characteristics of the rapid learner and the goals we should have for him. While these same goals are desirable for all children, they cannot be attained to the same extent by all. The rapid learner can think abstractly; he is curious, handles concepts and ideas easily, sees relationships and has an extraordinary memory. Persistence, insight into complexities, ability to generalize, willingness to challenge, are characteristics ascribed to the rapid learner. Such traits point the way toward a program which

places great emphasis on meanings, ideas, generalizations, concepts and abstractions. The program should stress acquisition of facts and skills as these relate to meanings and relationships. All rapid learners need basic scientific information but beyond that they need an understanding and appreciation of problem solving processes which we sometimes call the scientific method. They need experiences which emphasize the universal applicability of the problem solving process and research methodology to all areas of learning. One of the unique aspects of science teaching is the possibility of stressing the method of science so that it becomes part of personal behavior in various kinds of problem situations.

DEVELOPING THE SCIENCE PROGRAM EARLY

A science program for rapid learners must begin early, long before the secondary school. It may not be possible in the elementary schools to determine who will be the scientists and who the non-scientists. But the rapid learner is marked by intellectual precocity which could benefit from early discipline of work habits, attitudes, and study skills. We cannot and need not commit rapid learners to science careers during the elementary years but we can provide them with the kinds of experiences which enhance interest and stimulate understanding of the meaning and importance of science. By science programs which are sterile, routine, and practically divorced from desirable objectives, we have frequently nipped interest in the bud and driven youngsters from pursuing science and mathematics careers. It seems reasonable to assume that science experiences which embody the excitement, challenge, and discovery of modern science could have a positive result with young boys and girls.

Science has filtered down into elementary school programs but on a limited scale. At this level, science need not be confined to nature study or watered down experiments. Young rapid learners are capable of projects and independent study. They can pursue in greater depth and breadth problems with which they are concerned if they are helped with additional resources. Usually rapid learners can read and comprehend materials far beyond grade level; they can work with a variety of resources.

Surrounded by television, motion pictures, toy laboratories, books of all kinds, and all types of do-it-yourself kits, the youngster of today is ready for real science experiences earlier than ever before. We can either encourage and foster this interest and channel it into constructive paths or we can delay and discourage it and thus effectively kill interest and motivation.

The need for opportunities for individual searching leading to reflection and discovery is important at early ages. In our culture students often fail to discover that it is possible to find things out for oneself. We need to create conditions at all levels which help youngsters learn that they can satisfy their curiosity by their own efforts. It is not the magnitude of the discovery but rather the fact of discovery by the youngster himself that is important. One way to teach problem solving is to let students engage in the problem solving process —with problems real to them.

The elementary science program can be enriched in many ways—by differentiated assignments which encourage depth of activity, by group projects which deal with topics at an advanced level, by extended materials which are commensurate with the learner's abilities and desire to delve deeper, by opportunities to work independently with difficult materials. These few enrichment activities are only indicative of many ways of making it possible for rapid learners to have intensive experiences in science, to explore science interests, to experiment, to create, to discover for themselves. All rapid learners should have these kinds of opportunities and experiences at the elementary level. These are essential for their basic education and can serve to develop interests in further study.

Like all children, the rapid learner needs help in developing and focusing his special

interests. Once these have been identified and welcomed, he is in a position to push ahead with his choices. The elementary school program is typically one of developing basic skills, of general education, of exploration. There is a need for individual guidance and instruction which encourage the child with interest and some aptitude to develop his potential in science at this level just as readily as we encourage the young musician or Little Leaguer. The rapid learner who has already acquired an interest in chemistry need not have to wait until he reaches senior high school for worthwhile experiences.

We must recognize the real difference between encouraging and manipulating, between making experiences available and forcing youngsters. What is needed is to provide opportunities for real, challenging experiences as early as children are ready so that they can come to understand the meaning of science and acquire the attitudes, skill and knowledges which will enable them to develop further in whatever areas are chosen when interests and aptitudes are matured.

A rich elementary science program will make experiences available for rapid learners which are not available for all. Programs which use the seminar approach at the intermediate level hold much promise. Individual projects which involve use of advanced materials and equipment under teacher guidance are fruitful. Whatever modifications make it possible for students to develop positive attitudes toward the sciences and to acquire desirable work skills and study habits should be explored —both within and outside of the regular classroom structure.

A good elementary school science program makes possible sustained effort by individual and groups of students. Such programs enable youngsters to acquire the "feel" of science and the scientific method, to experience the thrill of discovery, to grapple with meaningful problems. How much differentiation is desirable in elementary programs still needs a great deal of study and exploration. But we can be sure that opportunities for individual creative thinking which may or may not be shared with other students in the class need to be developed to a much greater extent. We cannot predict accurately at the elementary level which students will be our future scientists, but we can be sure that the quality of the program at this level can do a great deal toward encouraging or discouraging their development.

The elementary school teacher is primarily a generalist. He is required to provide experiences of many kinds and he is responsible for practically all of the student's program. He is seldom a science specialist and frequently lacks the equipment and facilities necessary for an adequate science program. He needs in-service help to extend his competencies in science. As he develops understandings of the ideas of science, he will know how to integrate these with other foundations areas. Some schools have provided these in-service experiences using specialists from nearby colleges or have brought in researchers and specialists from industry to enhance teacher competence.

Another promising procedure has been that of closer cooperation between the elementary and secondary schools in the use of staff, equipment, materials, and developed competency. Rapid learners in high school have been used with success as seminar leaders, demonstrators, laboratory assistants, and equipment handlers in the elementary school. Such experiences, coupled with teacher guidance and instruction for the advanced students, can be valuable for both groups of rapid learners, elementary and secondary. High school science teachers have assembled kits and equipment for use by the elementary teacher, thus making additional facilities available. This cooperation also makes possible increased articulation between various levels. In many of of our school systems, this acceptance of responsibility and leadership by the secondary school science teachers has been invaluable in developing the total program.

CREATIVE APPROACHES NEEDED

Many of the same problems exist at the secondary level as at the elementary. We have tended too often to expose students to a routine acquisition of "basic facts" without meaning or method. Our so-called laboratory experiments have taken on some of the aspects of recipe filling with students knowing that if they manipulate data sufficiently they will arrive at answers already determined. We have not set the conditions in our science courses which encourage the student to work through a problem as a scientist might work it through—learning how to phrase answerable questions, how to use past experiences in the solution of new problems, how to test possible solutions, how to acquire meanings from problem solving.

Science at the secondary school level has a place in the general education of all rapid learners. How much differentiation should take place in the science programs of the potential scientists and non-scientists has not been determined. In most secondary schools, there has been no distinction made with the possible exception of numbers of courses and sequences taken by the students. Some schools have divided courses into "producer" and "consumer" sections but the latter have usually been watered-down versions of the former. Within the "producer" section no distinction has been made among rapid learners interested in science, others not especially interested, or still others who are disinterested. We have not viewed the advanced high school sciences (biology, physics, and chemistry) as part of special education but as part of the basic general college preparatory sequence for certain students. Differentiation in programs has come usually at the college level.

However, all rapid learners are not cut from the same pattern. They differ in aptitudes, interests, motivation, and purposes. They have some common needs but they have individual, different needs as well. Science programs will have to be developed at the secondary level which meet both common and individual needs. These may take the form of separate courses and sequences or differentiated learning experiences within the same course.

We need to carefully re-examine present organization, materials, content, and methodology for the means they provide in attaining desired goals for different kinds of rapid learners. New approaches are needed in both classroom and individual instruction. Cohen and Watson in *General Education in Science* [1] describe our present situation as follows:

> Rather than presenting the exciting adventure that science should be, all too many of our secondary schools tend to teach the student how to solve a limited number of numerical problems, ask him to memorize formulas and definitions, and generally overload his mind with dogmatic assertions—while the great adventure of logical deduction, concept formation, and theory construction never enters the classroom. It is no wonder that so many of our students, their minds offended by rote learning, come to us with open hostility for, and even hatred of, science.

For all rapid learners opportunities for individual research, independent study and project development should be provided. The nature of these activities may differ in terms of content or quality or depth. The non-scientist, for example, may deal with certain science topics in relationship to his special interests while the same topic is examined quite differently by the rapid learner interested in science. Students may tackle different kinds of problems and units. Independent activities should be coupled with seminar type activities in which students can deal with ideas and meanings, with problems and their possible solutions. Basic courses in science need restudy in terms of their effectiveness in developing understandings and techniques.

We need new approaches in developing science programs for rapid learners—approaches which will provide the flexibility required for appropriate experiences. We can explore teaching methods which en-

[1] Cohen, Bernard and Fletcher G. Watson, *General Education in Science*, Cambridge, Massachusetts: Harvard University Press, 1952.

courage concept formation, establish relationships, and produce meanings instead of rote memorization. The kinds of planning we do with students, the ways we provide for individuals and small groups, the resources we use, the evaluation procedures we employ all effect the nature of learning which takes place.

Differentiated assignments and activities are possible and desirable at all levels. These are not necessarily used at all times but only when differences in ability and interest warrant their use. Differences may be in problems assigned, resources to be used, or methods of attacking the problem. When this kind of flexibility in needs is provided for, a variety of instructional materials is necessary and different kinds of classroom organization can be used when appropriate. Sometimes students will meet as a total class or in small groups or individually. Here secondary school teachers can borrow some of the flexibility prevalent in the elementary grades.

Laboratory work is essential for developing science understandings. But meaningless manipulation of materials and equipment do not develop the skills, attitudes, or knowledge. Only as students face laboratory problems as challenging experiences can they acquire desired ends. Precision of measurement, effective technique, understanding of the processes, utilization of varied resources are the goals for rapid learners. Laboratory experiences which focus on problem solution rather than on material manipulation are needed.

Arguments of demonstration versus laboratory method still continue as if these were our only alternatives or mutually exclusive. Encouraging, indeed, is the use of the research seminar in the secondary school. Such seminars operate as a research team might function. Youngsters are encouraged to develop individual research projects in areas of personal concern, to design and carry out experimentation, to report and discuss their research with their peers, and to critically examine the work of their peers. Such a seminar cuts across usual subject divisions; it builds on the foundations acquired in previous courses but puts a premium on problem solving. We need to experiment with seminar approaches as well as with modifications in more traditional classes (even those involving college-level material) to attain desired goals.

Our traditional science sequence of general science, biology, physics and chemistry has recently undergone some modification. Advanced and special courses have been added; earth sciences, electronics, radio, physics, and similar courses have been provided, usually for rapid learners. Ford Foundation's Kenyan Plan has given importance to college level courses in physics, biology, and chemistry.

However, our course sequence and content can stand further re-examination. As we study this structure, we may find out that some of our present courses should be abandoned and new courses developed dealing with natural and physical sciences. We may find that the content of our existing courses can be acquired by rapid learners in far less time than now spent, opening possibilities for individual experimentation, advanced studies, or seminars. We may find that we will need to establish multiple tracks within a class or among several classes. We may find that we need to integrate science with other disciplines—mathematics, humanities, or social studies. Or, we may find that modifications are required only in the methodology used or the materials and facilities required. But we can only determine which approaches are effective for developing science programs for rapid learners if we will bring to the problem open, experimental minds and fresh perspectives. A joint effort by teams of high school science teachers, college specialists, science educators, and representatives from industry may open new channels for designing fresh approaches.

Field experiences are very desirable for rapid learners—not as excursions but as means for extending the science classroom. Technical libraries, industrial laboratories,

science museums, commercial processes, natural resources can all serve to enrich the learning of the rapid learner. We have heard a great deal recently about extending our science programs by drawing from the technological ranks of industry. A good research scientist may lack the qualities of a good teacher and be unwilling to acquire the essential teaching skills. However, the scientist can make a contribution for specific activities, working with an individual student or a class. In our haste to reject General Sarnoff's proposal, we should not dismiss those aspects of his suggestions which have real merit. Teachers can plan rather directly and specifically with the specialist for helping individuals or groups develop projects, for providing technical assistance, for making resources available, for leading lecture-discussions, for judging projects. These are supplemental activities which require close teacher-specialist cooperation.

The adequate use of instructional materials needs a great deal of exploration and study. For example, the use of open- and closed-circuit television has been proposed. While industry is exploiting this new media, schools because of numerous complications, are just slowly entering the field. Possibilities exist for rapid learners in television both as viewers and as producers. Just as television has brought great cultural resources into schools and homes, it can bring science opportunities into the classroom. The educational potentialities of television, films, radio and even correspondence school courses have not been adequately realized. We need to experiment with individual use of instructional materials. Just as we have begun to recognize that there are books and pamphlets which are appropriate for one or a few students, we are beginning to find that individualization applies equally well to the use of films, filmstrips, other instructional materials, and field trips. Not all students need to use the same materials or take the same trip.

Science programs can continue to be supplemented by extracurricular activities. Science and mathematics clubs, science contests (i.e., The Science Talent Search, Bausch and Lomb Scholarship Contest.) Science fairs can continue to play an important role in stimulating and motivating rapid learners. To these, some schools are adding technical work experience, participation in science-related community activities, apprenticeships, museum experiences. The extent to which these features of the extracurricular programs can be incorporated into regular science instruction needs careful study.

SOME OTHER CONSIDERATIONS

We have not discussed some of the usual areas which are considered in planning programs for rapid learners—problems related to acceleration, grouping, or special provision within regular classes. These are primarily administrative means for facilitating enriched experiences. Research has indicated that each of these administrative plans can contribute to certain desired academic goals without necessarily creating personal or social problems. Decisions concerning administrative modifications effect the nature of the instructional program. These decisions, however, should be made in terms of the ends desired and the possibilities of the administrative modification helping in goal attainment. Whether we use one or a combination of these plans depends on what it is we are trying to accomplish, the size and location of the school, the available resources both human and material. In developing science programs for rapid learners we should examine each of these administrative arrangements for its possible effect on flexibility in time, instructional activities, materials, class structure and learning opportunities. And, we ought to examine these with an open, scientific mind, avoiding the emotional heat which is sometimes generated by advocating any particular arrangement.

The balance between science and the re-

mainder of the rapid learner's program needs careful analysis. If we increase the challenge and level of difficulty, if we encourage experimentation and guided study, if we extend the range of resources—how can we relate these to the load the student is carrying and the total demands we make on him? Guidance, integration and articulation need consideration by the teaching and counselling staff. Differences in interests, motivation and purposes of rapid learners will mean that their commitment to science and involvements in other phases of the school program will vary. In some schools there is a keen competition among departments, each grabbing as many rapid learners as possible and holding on to them for specially sponsored programs. While it is normal for a high school student to begin to focus his efforts, he requires guidance in developing a balanced program in terms of his personal educational needs. Interdepartmental study of this problem is needed with all teachers concerned sitting down with school counselors to examine each individual case in order to come to agreement and learn to guide the student. The counselor frequently has a more balanced picture of the individual child than any single department. Through such guidance meetings decisions can be made with regard to courses and sequences for different lands of rapid learners.

There is frequently a question on the effects college admissions officers and faculties have on such programs. If past experience is any guide and present trends continue we can assume that colleges are interested in securing the best prepared students they can get. There is reason to believe that colleges will accept, with little hesitancy, rapid learners who have had science preparation which has not followed the normal sequence.

SCIENCE TEACHERS AND THE SCIENCE PROGRAM

The bulk of research implies, when it does not flatly state, that the key to an effective program lies in the quality of the teacher. If the teacher is inspired and inspiring; if he understands the meanings of science and the relationship of science to the world in which we live; if he is flexible and makes possible the flexibility needed for adequate programming; if he encourages individual excellence and devotes the time and effort required to guide the student to locate necessary resources; if he is sympathetic to rapid learners and their particular needs; if he knows his science and his techniques; if he is willing to adapt his teaching methods to stimulate problem solving—then the teacher has the attitudes and competence which comprise "good quality."

Study after study points to the importance of the teacher as a motivating factor in creating a scientist or science teacher. He needs to find and encourage as many youngsters as possible to acquire scientific skills. He needs to provide experiences in the kind of atmosphere in which interests are developed and students are motivated to high achievement.

Yet the shortage of qualified science teachers increases even faster than the general scarcity. We need to get more young people into science education and we need to retain what good science teachers we have. What rewards and motivations can we provide? The *Science Teaching Improvement Program* and the *National Science Foundation* have explored higher salaries, better working conditions, special awards, scholarship aid, and consultants for teachers. New York City is exploring ways of increasing the salaries through "additional services." The crisis for good science teachers has rallied industries, professional educators, science associations, and colleges to cooperatively plan means for recruiting and holding good, trained, qualified personnel. It is to be hoped they are successful in their efforts for as Dr. Vannevar Bush pointed out in *Science: The Endless Frontier:* [2]

[2] Bush, Vannevar, *Science: The Endless Frontier,* Washington, D. C.: U. S. Government Printing Office, 1952, page 21.

Improvement in the teaching of science is imperative; for students of latent scientific ability are particularly vulnerable to high school teaching which fails to awaken interest or to provide adequate instruction.

THE CHALLENGE IS GREAT

The times are such that the demands for scientists and mathematicians become increasingly insistent. We can make the error of indiscriminately recruiting or forcing or pirating students into science programs to meet manpower shortages. Recent magazine articles have described how the U.S.S.R. has reorganized its entire school system so that it concentrates on training scientists and then creating conditions which have made of such youth "an elite generation." We cannot follow this direction. However, we can begin to examine carefully the nature of our rapid learners and the nature of science and build the kind of programs which will stimulate students to move into these areas in increasing numbers because there is a promise of excitement and personal fulfillment. Rapid learners like the challenge of problem solving; they like to handle ideas and see relationships.

The need is great and the challenges which face science teachers as they develop programs for rapid learners are many. Some of the problems could be solved by salary schedules which attract and keep competent teachers. But money alone would not be enough. I. I. Rabi, the Nobel-prize winning physicist, pointed out in a speech reported in the *New York Times* recently that despite their recognition that science is playing an increasingly important role in our national economy and security, Americans hold science and the scientist in lower esteem than ever. "What disturbs and frightens the scientist," he said, "is the increasing tendency to treat science and the scientist as a commodity with all the appropriate export and import regulations which relate to important strategic materials." Our science programs have the difficult job of encouraging and developing those rapid learners who, by potential ability, interests, and aptitude can become our future scientists and teachers. It must also help the non-scientist understand the meaning of science and the emotional commitment of the scientist. It must contribute to an understanding which will restore the prestige of the scientist and the science teacher to its rightful place.

Questions of sequence, administrative organization, scholarship aid and others are all part of developing an adequate program. But an appropriate science program for rapid learners will emerge only as we understand our end purposes and use ingenuity and creativeness in building new programs. No single formula can be developed which can be followed by all schools and all science classes. The best place to begin is with a critical analysis of existing programs as a first step in creating new and different approaches.

In a struggle in which we are hopelessly outnumbered, our strength must come from free, creative, thinking individuals who understand the nature of science, its meaning in our society, its relationship to the future. We need to develop individuals with the moral and ethical values which are so essential to modern scientists. These are the kinds of persons our rapid learners can become if we are able to meet the challenge of developing adequate programs for them.

THE SECONDARY-SCHOOL SCIENCE PROBLEM

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The secondary-school curriculum continues to be the principal focus of concern for our Nation's supply of scientists, mathematicians, and engineers. It continues, too, to be the center of attention for proposals to increase supply of individuals with skills in these categories. Current writing provides evidence of growing awareness of the problems of organized education in the sciences at secondary-school levels: recent discussions, for example, include recognition of the predominance of small high schools in the United States, and recent statistical reports have reported percentage enrollments in terms which tend to discredit the scare headlines of the past few years. However, the characteristics of the problem remain unchanged: though the awareness of the high demand for scientifically trained people is widespread, the Nation is yet unsure of the causes of the demand, and unsure of the steps to be taken to satisfy it.

A truly massive literature has grown up around the problem, much of it hortatory or polemical, and attempts to survey the literature or to generalize effectively with respect to it are quite likely to prove inadequate. Without undertaking a complete summarization, however, several hypotheses and arguments can be identified in current discussion, and those readily identifiable, at least, permit test through rational analysis. Such analysis shows conclusively that new approaches to the problems of secondary-school science are needed if we are to understand those problems. It is the thesis of this paper that the analytical forms and processes of modern social science present unexploited promise for development of the sorely-needed new approaches.

* On leave of absence during 1957 from University of Chicago, Chicago, Illinois.

The mass of publication and speaking has at least two components: (1) an economic component, and (2) an educational policy component. In most discussions, one or the other of these components appears to be suppressed; and in those cases in which both components are involved, they usually are hopelessly confused.

One pole of the current discussions holds that allocation of high school graduates and college graduates among occupations is a problem of educational policy: that in the supply of the skills of the scientist and the mathematician, public need requires broad-scale proselytizing of promising students at precollegiate levels. The other pole insists that we have precisely as many engineers, mathematicians, and scientists as we are willing to pay for, and that the allocation of able, college-bound people among the various professional and sub-professional occupations should be left to the free market in labor.

For the moment, at least, it seems that the weight of publication and speaking is on the side of the proselytizers, and several projects are now under way to improve the recruitment effectiveness of secondary school curricula for scientists and mathematicians. So far as the teacher supply problem is concerned, the economic argument seems largely to have been lost under the blanket assertion that teachers—especially science and mathematics teachers—should be more highly paid. Since improvement of teacher pay requires actions of tens of thousands of separate school districts, activity other than publicity on this front seems non-productive, though a few summer work projects for science teachers have been initiated. There seems to be little attention being given to the possible effects of raising salaries of scientists, engineers, and mathematicians.

Assumptions Underlying Current Projects. Several non-economic hypotheses and conclusions are clearly discernible in the spate of discussion of the past few years. Most discussions and projects stress only a handful of facts: the decline in percentage enrollment in the sciences in secondary schools; training levels of science teachers, the distance between school curricula and the research fronts, and the like. Current project design seems to proceed from one or more of four readily identifiable and popular hypotheses presented to explain the facts of secondary school education in science; these hypotheses are presented and briefly discussed below.

Hypothesis I. Secondary school work in general is very easy; science is inherently difficult. Students choose the easiest subjects; therefore enrollments in science may be expected to be small.

To raise significant questions with respect to this hypothesis, it is not necessary to argue that secondary school students all are responsible, seriously concerned young people. Certainly large fractions of our secondary school millions are serious and responsible; but this fact can for the moment at least be neglected. The more serious error lies in the major proposition: that science is inherently more difficult than other school subjects. This hypothesis would be hotly attacked if applied to graduate curricula in any university. However, the hypothesis does not place quantum mechanics *vis-à-vis* expert criticism of literature: it places high school science *vis-à-vis* high school English or social science. Since any high school course is a selection of materials from a vast field, such a course can be made sufficiently difficult to dissuade any given group of students, regardless of aptitude. To test the hypothesis, then, one asks: Is high school science more "difficult" than work in other subject fields? If this question can be answered affirmatively, there is an immediately following query: Why should science teachers make their courses more difficult than, say, English teachers make their courses? Either group can make its courses as difficult as it wishes. There is no immediately apparent reason why high school science should be inherently more difficult than many other high school courses. The answer to the second question might help in dealing with today's difficulties, but no answers are yet forthcoming.

Hypothesis II. High school teachers are and have been inadequately trained in science; the enrollments in high school science would have remained high if adequately trained science teachers could be retained in the schools, and enrollments can be increased if effective on-the-job training in science is provided for science teachers.

It is true that many high school science teachers are inadequately trained in science; the same assertion can be made for teachers in virtually any other field in secondary school—including that whipping post, physical education. Surveys cited in support of this view typically do not compare teacher training between fields; they look only at science teachers, and conduct their appraisals in terms of theoretically desirable training levels. "Adequate" thus usually turns out operationally to mean college transcript report of an undergraduate major in science. However, it is not true that all science teachers are inadequately trained, by this standard or any other, or even that most science teachers in any particular good-sized school system are inadequately trained. The larger city systems of the United States, for example, typically exhibit well-trained staffs, and in some such systems master's degrees in the subject taught are prerequisite to employment. These systems have on the whole experienced the same declines in percentage enrollment in the physical sciences that public education as a whole has experienced, though their graduation requirement patterns have in several cases stabilized enrollments in general science and biology. Hypothesis II, however, seems to be very attractive to academic personnel, especially

when combined with the limited studies reported above. Its usefulness as an explanatory hypothesis is not great, for it assumes that now and for some time science teachers have been significantly less well trained than their colleagues. While this could conceivably be true, it probably is not true, and in any case it needs demonstration before use as a basic proposition in an argument whose outcomes are so important. Hypothesis II therefore cannot be held to provide effective explanation of the problem of decline in secondary school science enrollments relative to enrollments in other subject fields.

Hypothesis III. Educationists have destroyed most of the disciplinary values in secondary schools; science, as an important bearer of disciplinary values, has been mortally injured by the destruction of all intellectual disciplinary values in the schools.

Like its predecessor, this hypothesis falls before the fact which it has been set up to explain. To question the efficacy of this hypothesis, it is not necessary to enter upon the discussion of formal discipline, as an aim of education, for the fact to be explained is not absolute enrollment in science. This number is larger than ever before, due to the larger total enrollment in the schools. The fact requiring explanation is the worsening of the relative enrollment position of school science with respect to other courses. All fields are equally vulnerable to the "Educationists"; and many school courses lay claim to disciplinary contribution as great as that provided by science and mathematics. Some of these, like English, enjoy enrollment hegemony in secondary education.

Hypothesis IV. College and university science departments have not been interested in teacher training; the decline in enrollments can be laid at the door of departmental unwillingness to locate and train secondary teachers in the colleges.

It is probably true that most departments of science, particularly in the stronger universities, have not busied themselves with training secondary school teachers. This fact, however, is equally true of most other university departments. The history of teacher education in the United States does not show important differences between subject-matter departments in colleges and universities. There is one conspicuous difference between science teacher training and, for example, mathematics teacher training: to train a science teacher, several university departments must co-operate, due to the structure of the secondary school curricula. This, however, also turns out to be a non-productive line of speculation; for the same problem is faced in the development of social studies teachers; and social science is one of the high-enrollment areas in secondary education. Mathematics teaching, a one-university-department specialty, is one of the fields of current concern due to low enrollment.

Undoubtedly, several other hypotheses could be located; but current writing and project design seem to emphasize these four. Unfortunately, none of these, or even the four together, provides adequate basis for understanding the situation in which the schools are involved.

A Summary. Survey of the current discussion, however, permits one to conclude that manpower students and national leaders in industry and government agree that more productive curricula in science and mathematics in the public schools are necessary. In general, they agree that this productiveness is to be appraised in two ways: through observation of the numbers of competent candidates who matriculate for the science and mathematics curricula of higher institutions; and through evidence of improved general understanding of science and mathematics and their functions in the United States of the Twentieth Century. This agreement is sufficiently widespread to constitute at least a provisional base for erection of new educational policy. There is no agreement on the details of a desirable new educational policy, nor is there agreement on cause of the present difficulty, or on desirable design of corrective measures.

The anxieties produced by our world situation have developed a sense of urgency—even of emergency—in supply of scientists, mathematicians, and technicians. This sense of urgency has been an important stimulus in the recent publicity, and has resulted in several substantial projects designed to relieve current pressures for manpower in these categories. However, recent studies of instruction in arithmetic have led some students to the gloomy conclusion that a generation or more may be needed to make noticeable improvement in instruction in this field alone. Informal sociological analysis of the situation in school science suggests that a similarly extended period may be necessary for significant alteration of the national pattern in this field as well—unless new information can be brought to bear. Students of cultural patterns would probably insist on *a priori* grounds that only slight and temporary dislocation of present-day school patterns could be expected to result from the kinds of educational activities and publicity now being used. It is true, however, that these dislocations might be sufficient to produce a short-range rise in supply which can sharply reduce short-range need for technical personnel.

Unquestionably, the basic national demand for technical and scientific manpower has risen sharply in recent years and will continue to rise; but today's conspicuously high demand—the mainspring of the current stimulation efforts—is in large part the creature of the low birth rates of the thirties and the currently high military demand. The effects of the first of these will certainly pass, relatively soon; and the second could virtually disappear overnight as the aftermath of sharp reduction in international tension. These facts illuminate a serious danger in planning broad-scale educational stimulation to meet short-range increases in demand. Heavy educational emphasis based on current demand could, in a very few years, produce an extremely damaging public view of educational activity in this field as over-selling. Such a view could easily prevent substantial improvement of science and mathematics education for much longer than a generation. Too, loss of the main-spring would sharply reduce the availability of means with which to attack the deep and persistent inharmonies which underlie the present unsatisfactory situation in school science and mathematics. The problem is short-range, current supply, of course; but it is also long-range, stable supply. Thinking in terms of the short-range problem can give no guarantee of success in solving the long-term need.

The conspicuous need of the present situation is a need for basic investigation—investigation which will provide understanding of the enormous disparities which have arisen between in-school and out-of-school science and mathematics in our society. This investigation should involve best available insight into social structure and social processes, for the problem to be investigated is two-sided: it is a problem in social phenomena as well as one of natural science and mathematics. The basic effort must be to build an accurate picture of the routes, agents, and processes through which science moves from the laboratories into the larger society in which the laboratories are embedded. Given this picture, we should be able to bring critical routes and processes under conscious control to meet social needs. Without this picture, attempts to spell out the new policy agreement in educational programs must rest upon *ad hoc* hypotheses and hunch.

Another Look. None of the currently popular or presently conspicuous attempts to deal with the situation takes adequate account of the social massiveness of the basic fact: science and mathematics in the schools can in no way be said to represent the enormous place of science and mathematics outside the schools. For years, educational theory has emphasized responsiveness of curriculum and method to community and other social pressures; however, even under the enormous pressures of commercial advertising, an unprece-

dented flood of new gadgets, an enormous rise in out-of-school social authority of the natural scientist (even cigarette sales are increased by men in white lab coats!) and a favorable climate in educational philosophy, the schools have not developed vital programs either in elementary or in secondary science and mathematics. This is a fact of first magnitude. In the perspective provided by (1) the sixty-year span over which in-school science and mathematics and out-of-school science and mathematics have been diverging, (2) the millions of students involved, (3) the tens of thousands of teachers of science and mathematics, (4) the tens of thousands of secondary schools of the Nation and (5) the immense authority and prestige of science and mathematics in the national culture, the fact of the divergence of in-school and out-of-school science and mathematics presents a need for explanatory hypotheses which reach far more deeply into our society and its schools than any of those currently proposed.

Possible Routes for Productive Inquiry. In recent years, analytical concepts and processes have been developed to explain social situations as massive and as persistent as the one under examination. These are the theoretical analyses and the investigative techniques of anthropology, sociology, and psychology, which typically find their explanations of the massive behavior patterns in any society in the processes of social selection for established social roles, in cultural conditioning, and in deeply rooted, habitual, non-rational behavior forms.

For example, both formal investigation and commonsense observation repeatedly demonstrate the fact of important differentiation of social role by sex. These differentiations are often among the most rigidly prescribed behavior patterns in a society. It is reasonable, therefore, to entertain the proposition (1) that role differentiation by sex is at least relatively rigid in our own society; and (2) that recruitment of scientists and engineers and the transmission of scientific knowledge are affected by this role differentiation.

When one tests these propositions through an informal investigation of the schools and of institutionalized science and technology, several interesting facts emerge. One finds that, so far as membership in scientific and engineering societies can show, science and mathematics are men's business in the United States. This tentative judgment can readily be reinforced by informal appraisal of rearing patterns for females in the middle-class homes which provide the bulk of our college students: daughter's bicycle is repaired by Dad or elder brother; if a boy's bicycle fails, son is handed the tools and told to fix it himself. The women's pages of the newspapers adjure nubile maidens to keep their intellectual competencies carefully hidden from their suitors. Few men in the United States use as rich a variety of devices as the middle-class housewife; yet the housewife infrequently will undertake the repair of even a faulty electrical extension or connector plug.

The care of young children in the United States is also polarized with respect to sex, but in the opposite direction. Such care is female work. Elementary school teaching staffs typically employ eight times as many women as men; the men's roles are chiefly those of the administrators, directors of the boys' physical education, and the school shop teachers. Increasing the proportion of male teachers in elementary schools has turned out to be a very difficult task.

Assuming adequate empirical verification of the propositions, one can conclude that establishment of effective science programs in elementary schools will continue to be extremely difficult, because, in our society, such programs require either that women do men's work, or that men do women's work. One can also develop interesting—and testable—hypotheses concerning the probable effectiveness of female science teachers in the recruitment of prospective male scientists, and the probable effective-

ness of male science education specialists in the improvement of elementary science curricula. Perhaps the relative lack of responsiveness of the schools to modern demands in science is due to a conflict in its directives from the social order. Ordinary measures cannot be expected to resolve such a conflict.

The preceding analysis, if sound, would also provide grasp of the observed difficulties in interesting women in scientific work generally. The proposition that division of scientific labor in terms of sex is not necessary is supported in part by the newsphotos of Soviet scientific meetings: women form an impressive fraction of the audiences. We hold to the view that streetcleaning is men's work; that this is a parochial view is also attested by the newsphotos! If the hypothesis that science is men's business in the U. S. can be affirmed, a non-rational division of scientific labor by sex actually is depriving the United States of important intellectual resources in science and mathematics. The alteration of such a behavior form requires alteration of the basic mores of important fractions of our national population; though this is an enormous task, it perhaps could be intelligently undertaken with some hope of reasonably early gain. Such an undertaking, undergirded by factual research, would promise far more—and more rapid—national growth than action taken on *ad hoc* hypotheses of the type which now govern project design in school science and mathematics.

Other provocative hypotheses can be gleaned from application of modern analytical forms. For example, it may be that the selection routes for teachers of science and mathematics actually reward personality types which are predictably inharmonious with the public schools in which they expect to work. The satisfactions valued by teachers of science and mathematics in working situations may be conspicuously different from those of other teachers, and so on.

What Needs to Be Done. To exploit the new educational policy agreements with respect to science, several needs are clearly identifiable.

First, we need facts—facts concerning the social setting of science and mathematics education; facts concerning the ways both high-potential and other youth learn science and mathematics; facts concerning relative effectiveness of various devices for science and mathematics instruction at various levels of human development, and the like;

Second, when we have new information, we need to design improved curricula, improved teacher education and selection processes, improved instructional materials, and program appraisal processes adjusted to our new needs;

Third, we need to develop a larger cadre of specialists in education in the sciences and mathematics who can render yeoman service in the exploitation of the new information and new materials and can themselves provide new foci of activity;

Fourth, we need to develop adequate finance for 10–20 promising centers for continuing research and development in science and mathematics education;

Fifth, through investigation and controlled experiment we need to locate and exploit communication routes and processes for maximum rate of introduction of the new information and materials in the public and private schools of the Nation.

Activities designed to satisfy these needs are necessarily interdependent. Facts concerning the social setting of science instruction, for example, must be developed in light of current scientific knowledge; methods of learning depend on available scientific knowledge; the social setting, and available instructional materials and devices; development of new workers depends upon their scientific training and upon their knowledge of modes of interaction among scientific knowledge, the agents of transmission of scientific knowledge, available teaching materials, and so on. The conditions for effective communication of a set of ideas will affect choice among alternatives for a new curriculum, new instructional materials, or an in-service training program for teachers.

The intimacy of interaction among the activities necessary to making a start on the satisfaction of these needs is not the

only complication. In addition, there is equally intimate interaction among all other aspects of the school programs and the science-mathematics programs. Again, an example: it is probable that re-education of an entire secondary school staff with respect to science and mathematics will be necessary for significant and lasting improvement of these programs, for the counseling activities of the teachers in all fields bear importantly upon enrollment in science and mathematics. Success in the necessary investigation and in the program designs which follow such investigation will depend in large degree on ability to keep clearly in view a wide range of relationships among people, organizations, and fields of knowledge.

The proposed actions, however, are predicated on the assumption that we can build an accurate picture of science education in our society, for today's crop of arguments, exhortations, and projects do not promise lasting change. No current undertaking promises forces which in any way approach the magnitude of the social forces developed in support of science by science and technology themselves during the past sixty years—and today's situation has proved even these enormous forces to be virtually impotent in the maintenance of secondary school science.

For more than one hundred years, Western society has been seeking more effective accommodation of the enormously innovative activity maintained by natural science and technology. In that search, our branch of the West has recently been startled by finding itself economically and militarily dependent on the processes of innovation it previously had been seeking merely to accommodate. The insecurities developed by the sudden awareness of a previously unrecognized dependency has turned many to hunch, to guess, and to polemics to relieve those insecurities. However, our growing knowledge of the history of science and technology has over and over demonstrated the conditioning of science itself at any given stage by the society in which it is embedded. Staffing today's scientific effort and the movement of today's science and its fruits from laboratory to the larger society are not merely conditioned by their social setting: these movements are themselves social phenomena. We are not limited to guess, to hunch, and to polemics for control of these processes: investigation through the concepts and the procedures of modern social science can develop important insights, and may in due course provide the knowlledge through which the processes may be brought under intelligent control.

THE STATUS OF SCIENCE TEACHING MANPOWER IN NEW YORK CITY

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THE High School Division is greatly concerned with the serious shortage of science teachers. National, state and local leaders in government and education have been emphasizing the importance of science and technology in this nuclear age. This importance springs from the realization that the high standards associated with the American way of life are dependent upon scientific research and technology. Our belief in our unassailable position in all areas of science received a rude jolt when the news of the first atomic explosion in Russia became known. Following on the heels of this news, came reports that Russia was making an all-out effort to train

her young students in science and engineering. Dr. M. H. Trytten of the National Research Council in his talk before the Fifth Thomas Alva Edison Foundation Institute on "The Present Situation in Elementary and Secondary Education," said, "We now know that the USSR is fully aware of the role of science technology in the national effort toward economic and military power. We know that the USSR is translating that knowledge into action at all educational levels, and especially at the level of the secondary school."

Educators realize that we cannot stimulate specialization in these areas without an adequate number of well-trained science teachers in our high schools. Here our future scientists and engineers are discovered, stimulated, and nurtured. The number of scientists and engineers graduating from our colleges is decreasing while the opposite is true in Russia. If this is permitted to continue, our position of eminence will disappear within five years and we are in danger of losing the cold war by default. Our high schools will be bulging with students in the next decade. The limiting factor in the production of trained scientific manpower will be the high school science teacher. During the past year the office of the Science Supervisor was unable to assist any of the 85 academic and vocational high schools with the name of a single teacher to meet calls for assistance.

In order to appraise the magnitude of the problem and to consider possible methods for solving it, a questionnaire was sent on May 23, 1955 to 85 high schools (54 academic and 31 vocational) to secure answers to five questions. The questions in the questionnaire and an evaluation of the replies to each question follow.

I

How many classes in your science departments were taught by teachers holding no science license (substitute or regular) for more than five successive days during this academic year?

The schools reported that they could rarely secure a licensed science substitute to fill existing vacancies and occasional absences. Thirty-four academic high schools reported that they employed 35 non-science substitutes for one or more terms. This signifies that 165 classes containing approximately 5,800 students were taught science by teachers who did not possess a science license. This number represents approximately 6 per cent of the total number of science students on register on March 31, 1955 in the academic high schools.

The situation was far more serious in the vocational high schools. Twenty of the 31 schools reported that they used 61 non-science substitutes for one or more terms. This indicates that 305 classes, containing approximately 9,900 students were taught science by teachers who did not possess a science license. This number represents approximately 33 per cent of the total number of science students on register on October 29, 1954 in the vocational high schools.

The above statistics clearly demonstrate the difficulties which our high schools experienced during the present school year 1954–1955 in staffing our science classes. Question II was propounded to view the problem as it will exist in September, 1955 when the schools reopen for the year 1955–1956.

II

How many science teachers, *not presently available*, will you need next term?

Twenty-four academic high schools reported that they will require 36 science teachers, including 23 Biology and General Science, 4 Chemistry, 7 Physics and 2 Earth Science teachers for September. This shortage will affect approximately 6,300 students in the academic high schools.

As may be expected after studying the replies to Question I, the situation facing the vocational high schools is much graver. Twenty-one vocational high schools will

face a shortage of 59 science teachers, including 16 general science and 43 basic and related science teachers, for September. This will affect 9,000 students.

There have been indications that lists of substitutes in all science areas will be promulgated before September. From past experience and present trends we may safely predict that the total number of science teachers required would, at most, only be reduced by one-third. There remains therefore an urgent need for 63 science teachers to staff 315 science classes with a total science registration of approximately 10,500 students in our academic and vocational high schools when we open in September 1955. With no additional supply of science teachers on the horizon, and with greater and greater numbers of students knocking at our doors and with an acceleration in the number of retirements of our present corps of science teachers who are getting on in years, we are now facing a crisis in science education in the New York City high schools.

Questions III, IV and V were designed to elicit recommendations for easing this crisis. However, before a profitable discussion of what can be done to overcome this crisis is held, an understanding of the underlying causes is necessary. We have seen in Questions I and II that recruitment of teachers of science has almost reached the vanishing point. There are five main reasons for this. In the first place, we are in the midst of a long period of abundant prosperity. College graduates with a B.S. degree are offered $350 a month by industry with all kinds of fringe benefits. The starting salary for the high school teachers with both B.S. and M.A. degrees in New York City has been $304.16 per month which dwindled to a take-home pay of less than $250 after pension and other deductions.

In the second place, many college graduates decide to go into the Armed Services immediately instead of postponing the period of service. Deferments for science teachers have not been accepted as a national policy by the Armed Services.

In the third place the morale of the high school teacher in New York City has reached an all-time low. C. H. Sorums of the AAAS wrote recently, "One fact, however, seems to stand out in any discussion of the problem; if we want good teachers we must accord them the prestige to which the importance of the job and the training that it requires entitles them. Not until the young graduate of a university can come to his family, or his friend, or his major professor and announce that he has just been hired to teach chemistry at Any Town high school with the same swelling of pride with which he now announces the fact that he has been hired as a chemist or a chemical engineer by an industrial concern, will the teaching profession attract an adequate number of qualified young men and women."

In the fourth place, classes are excessively large. It is difficult to provide students with the attention they require when classes are overcrowded.

In the fifth place little differentiation is made between the teachers who grow professionally, attend professional meetings and conduct extra-curricular activities and those teachers who come and go in accordance with the daily time schedule. There are too few avenues for advancement. Those opportunities that exist place too little weight upon superior service.

Information supplied by our schools of education indicates that under present conditions, the shortage of science teachers will get progressively worse for the next 10 years. Dr. Ray Maul and his colleagues in the N.E.A. Research Division have brought statistics up to date in their Report of the Eighth Annual National Teacher Supply and Demand Study for 1955, reported in *Chemical and Engineering News* for June 20, 1955. They report that the number of students in the entire 48 states completing science teaching certificate requirements this year are 3,912

with 1,690 in General Science, 1,371 in Biology, 602 in Chemistry, and 249 in Physics. There were no figures available for related technical science teachers. Dr. Maul pointed out that only 45 per cent of the men and 65 per cent of the women who qualify for high school teaching positions actually accept teaching positions. A little arithmetic will demonstrate that we cannot depend upon the June 1955 products of our schools of education to alleviate the impending crisis.

As scientists we know that the first step in the solution of a problem is an understanding of the problem. The dimensions of the problem were outlined above. An analysis of possible approaches to the solution of the problem will now be presented. The recommendations of the science chairmen and principals were submitted in their replies to Questions III, IV and V. The proposals and recommendations follow.

III

The Standing Committee on Science in Section IV in minutes of the May 1955 Meeting makes two suggestions to provide additional science teachers. (1) Substitute science teachers should be recruited from the ranks of our colleges and universities who have adequate backgrounds in specific science areas but have no courses in education to their credit. These teachers would be required to take the requisite number of education courses before qualifying for the position of a regular teacher. (2) Married women teachers who held science licenses and left the teaching profession should be invited and encouraged to return for a term or day-to-day substitute work. Will you kindly comment on both suggestions?

The minutes of the Standing Committee on Science amplified suggestion III(1) in three ways. Candidates would be selected on the basis of examinations conducted by the Board of Examiners. These substitute teachers would receive their educational indoctrination and training in the school under the direct supervision of the science chairman. They would be required to take the requisite number of education courses before qualifying for the position of a regular teacher and would be given a period of 3 to 5 years to do so. Thirty-five academic and 24 vocational high schools said "yes," 11 academic and 3 vocational said "yes" with certain qualifications, and 8 academic and 4 vocational said "no." Some of the qualifications were:

It would open the door to poorly qualified teachers.

It would accept teachers who were too young and immature.

It would require extra allowances for chairmen.

It should only be used as a last resort.

It is only a stop-gap measure and not a cure.

It should reduce but not eliminate education course requirements.

It will encourage non-education majors to use teaching as a stepping stone to a job in industry.

Those who wrote "no" claimed:

It would lower standards and bring inferior teachers into the schools.

It is only a stop-gap downgrade for the teacher.

It would endanger the students and valuable apparatus because of their inexperience.

It would not contribute to the enrichment of science teachers.

It would be ineffective. How to get science teachers is not a mystery. When the community wants them badly enough it will get them.

It is not acceptable because methods of teaching and teaching experience are too important.

In answer to the suggestion III(2) of the Standing Committee on Science pertaining to the advisability of encouraging teachers who resigned to return to teaching, 35 academic and 21 vocational science chairmen said the idea was a good one and should be tried, 16 science chairmen said they accepted the idea with reservations, and 6 science chairmen did not agree with the suggestion at all. Among the reservations set forth by the chairmen were:

Many of them have been found to be so lackadaisical and indifferent as to make them almost a liability, not an asset.

Doubt if we will have practical results.

None available in Chemistry and Physics.

Unless the time elapsed is not too long I would rather see younger than older people invited to teach.

Ineffectual, supply limited. Experience with some married women substitutes on a day-to-day basis is not too favorable.

Will demand too many "concessions" as to type of program, etc.

Only as a stop-gap measure.

Likely to do more damage than good.

Cannot do an adequate job.
Will result in frequent absences. Cost of a maid to take care of household would not make it worthwhile.

The science chairmen who said "no" gave among their reasons the following:

Meaningless.
Salary not attractive enough.
Suggestion is vague.
Inadequate to meet long-term situation.

Since New York City possesses a large corps of alert, professional and dedicated science teachers and chairmen, there was a high probability that they constituted a source which could be tapped for additional suggestions. Question IV was designed to tap that source and obtain their suggestions for meeting the serious situation which faces science education today.

IV

Realizing the present inadequate salary scale for all teaching and supervisory personnel and the need for immediate adjustments, can anything else be done to encourage more young people to become substitute science teachers?

Seventy-six of the 85 high schools contributed suggestions in answer to the above question. Most of the answers fall into six major categories, Morale, Examinations and Licensing, Guidance at the High School Level, Guidance at the College Level, Fellowships and Industrial Employment, and Advertising and Public Relations. Duplication in answers have been avoided where possible. The suggestions follow.

Morale

Salary increases by themselves are not the whole story. It is also necessary to make the teaching career more attractive by raising the prestige of the teacher, by improving his morale, by opening more possibilities for advancement. Such measures are particularly necessary in the high school, where teachers must have a higher degree of subject matter competence, and hence usually acquire skills which are readily marketable in other fields. Such measures cost money, and until additional monies are available, it is useless to make suggestions.

Provide more promotional opportunities for the high school teacher.

If teachers are overburdened, they are unlikely to encourage their better students to enter the field of science teaching, or to fire them with their own enthusiasm.

Make teaching more attractive. Smaller classes, more free time to be used by laboratory and class room demonstration, to help pupils prepare for science fairs, etc.

It is my considered opinion that as long as a physics teacher with a master's degree receives the same salary as a kindergartner, there will be a shortage of science teachers.

Teaching can be made more attractive by the reduction of such non-teaching tasks as clerical work and "patrols."

Remuneration is never in money alone. Pleasure in the work itself and the conditions under which it is done, satisfaction that comes from feelings of accomplishment, prestige—all these are at least as important as salary, and can be provided by society. I'm afraid that Teacher Recognition Day, far from helping, only emphasizes the low estate to which the profession has fallen in public esteem.

The inadequate training and poor attitude of some of the present day high school pupils have much to do with the growing reluctance of young people to enter the New York City teaching system.

Call attention to such elements as security, a liberal pension, and holidays.

Appoint or assign enough personnel to reduce class size.

Give teachers with little or no experience reasonable assignments to facilitate adjustment.

Provide a higher salary scale for high school teachers.

There is no other alternative than to make the high school position as rewarding as industrial or other professional opportunities.

Do not threaten to appoint young teachers to difficult areas.

Allow uneducable 16 year olds to leave school.

Fundamentally, nothing can overcome the salary problem. There is no way of getting something for nothing. Moreover, any palliative may help temporarily, but will hurt in the long run. Thus, employing unqualified teachers will result in a reduction in the number of students who will be stimulated to elect science or to select science teaching as a career, and hence will result in fewer science teachers in the future.

Examinations and Licensing

We should be able to promise swiftly conducted examinations during the candidate's final college semester.

Give high school teacher exams more frequently and process these exams more quickly. At present, many teachers are lost to other school systems, where positions are more quickly obtainable.

Reduce the time interval between the announcement of examinations and the publication of lists.

Principals of schools should be permitted to issue a temporary license to a qualified person for the period of time between the applicant's initial application and the time it takes the Board of Examiners to issue an emergency license.

Grant increased salary credit for previous experience in industry or teaching.

Many substitutes prefer to enter the elementary schools where examination and course requirements are less stringent.

Guidance at High School Level

High school science teachers should encourage their good students to enter teaching rather than make disparaging remarks about their profession.

Have high school pupils realize the national need for more science teachers and scientifically trained personnel through talks by chairmen, guidance counselors, teachers, etc.

Send teams of speakers around to the various high schools to speak to students just the way the engineering societies are now doing.

Institute a planned guidance program in the secondary schools to "sell" science teaching to the students. Girls should be encouraged to enter the profession.

Start recruitment program in senior year of high school.

Require 3 or 4 years of science of all academic students.

Guidance at College Level

Our Board of Education should set up a committee which will work cooperatively with the colleges in encouraging science majors to prepare for teaching either on a permanent or temporary basis.

Competent speakers might be sent to the colleges to publicize the advantages of teaching science.

Invite college students to observe inspiring science teachers in action, to see alumni-teacher reunions on days set aside for that purpose at various schools, etc., in order to reveal that there is much pleasure in teaching.

Establish scholarships to pay the cost of undergraduate education courses for students majoring in science in private local and nearby colleges.

Invite college students to professional teachers association meetings, and to science fairs. Talks by outstanding scientists asked to help in this important recruiting drive, may encourage attendance at such meetings and may help arouse a desire to teach science.

Send science chairmen to the local colleges to recruit science trained students and interest them in teaching.

Promote visits from teacher training schools to see work done in science classes.

Encourage B.A. candidates, who have not majored in science to complete science requirements for teaching in senior year by contact with university employment agencies, visits to colleges by Science Supervisor, etc.

Offer possibility of securing supervised pupil teaching credit in the evening high schools.

Fellowship and Industrial Employment

Get cooperating universities to give fellowships for continued after-school hours study and for summer study.

Ask the industries (chemical, electrical, etc.) that need scientific personnel to subsidize all science teachers through the payment of a bonus on top of the Board of Education salary.

Permit teachers of applied sciences to return to industry periodically on yearly sabbaticals.

Get cooperating industries to give post-school and/or summer employment.

Guarantee substitutes a summer job.

Advertising and Public Relations

Advertise in all science and engineering journals—offering up to 5 years salary credit or even—year for year credit (on teaching salary scale).

Advertise in the subways. Have posters printed and distributed to colleges, public libraries, etc.

Develop better public relations.

The following suggestions did not fit into any of the above categories:

The teacher-in-training license should be re-established (with salary) in place of present student-teacher arrangement.

The possibility of easing military draft requirements for young men training as science teachers might be explored.

More women is the only solution I see.

Reduce the requirements for laboratory assistant. Many young people enter the teaching profession through the position of laboratory assistant.

The fifth and last item in the questionnaire was included to ascertain whether there existed an appreciable number of married women who were science teachers before they resigned from the high schools (see Question III(2)). The proposal and the results follow.

V

State the names and addresses of married women teachers who resigned from teaching positions in your school during the past 15 years.

Only 23 names were submitted by the 85 high schools. This shows that the above source is not likely to help very much. As indicated in the replies to Question III(2) on page 122, the source should be explored but the chairmen were doubtful of its productivity.

I would like to make an additional suggestion.

Many college graduates with adequate science backgrounds enter the Armed Services each year. The Armed Services provide schools of instruction designed to teach quickly, thoroughly and effectively the requirement for specific duties which must be assumed by the servicemen. The Armed Services at the same time attempt to keep the morale of the men at a high pitch. One way of doing so is to bridge the gap between the required period of service and the return to normal civilian life. The men have a considerable amount of "free" time which could be put to profitable use for them. I suggest that they be encouraged to enter the teaching profession. At the same time education courses could be offered to them. Committees composed of representatives of the Armed Services, schools of education and boards of education could draw up courses of study in education to meet necessary requirements for high school science teaching licenses.

CONCLUSIONS

The data collected in the questionnaire clearly indicate that the New York City high schools are facing a crisis in science education today. Many suggestions were submitted by the science chairmen and principals. These suggestions emphasized the need for (1) instituting an adequate salary schedule, (2) improving working conditions, (3) raising the morale of the teachers, (4) permitting college graduates with adequate training in science to become science substitutes even though they have not taken education courses, (5) processing candidates for teaching positions quickly, (6) guiding students in high schools toward science teaching as a career, (7) providing better articulation with the colleges toward guiding college students into science teaching careers, (8) interesting industry in providing fellowships and industrial employment, (9) advertising the present situation and the advantages of science teaching as a career, (10) providing guidance and education courses in the Armed Services, (11) inviting married women science teachers, who have resigned, to come back, (12) re-instituting the teacher-in-training license, (13) easing the military draft requirements for young men training as science teachers, and (14) encouraging more women to become science teachers.

The nature and type of suggestions set forth in this study require study and action at the highest levels. The Board of Superintendents should consider and evaluate the suggestions and initiate measures to implement those which show the greatest promise.

The City of New York took the first major step to solve the impending crisis. It recently announced new salary schedules to take effect in two installments on July 1, 1955 and on July 1, 1956. On the latter date, the entrance salary for the college graduate with an M.A. degree will be $4,400 and the maximum salary will be $8,000. This new salary scale, although below that asked by the teachers, will undoubtedly sitmulate the recruitment of science teachers *IF* a concerted effort is made, at the same time, to secure a greater measure of self-respect for them personally, for their work in the classroom and for their contributions to our American way of life. Both are necessary for the growth of the *professional* teacher.

Through all of the suggestions runs the thread of belief that the morale of the high school teacher must be heightened, his self-respect must be recovered, his rightful position in the community must be re-established, and his contribution to the education of our American youth must be firmly recognized. He must be appreciated by the Board of Education and not be taken for granted. He must be assured that the measure of success that he achieves in the classroom will be recognized immediately and will constitute a record which will stand him in good stead as he climbs the educational ladder. He is a fine American, an excellent citizen, a Prophet in his own right. He is responsible for the present generation of children and is conscious of his responsibilities. He is entitled to the high esteem of his children and fellow citizens.

SOCIAL SCIENCE AND ATOMIC POWER

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As social science seeks to come to grips with the problems of modern society, what is it learning about the social consequences of atomic power? As it attempts to advance along the ladder of empirical research, what insights is it gaining into the atomic age? What are some of the constructive social aspects of atomic power? And finally, what bearing does atomic power have upon the historic process?

ATOMIC DESTRUCTIVENESS AND SOCIAL LAG

The atomic bomb has magnified man's ability to destroy to the point that it is possible to completely demolish cities of warring nations or exterminate large segments of national populations. This menace to civilization has created an unprecedented fear and a deadly distrust throughout the world. This fear and distrust must be understood and controlled if we are to escape its wrath.

Through the years, man's ability to control destructive forces has been increasing, but we have never managed to keep these controls effectively operating against the increasing destructiveness of technology. The lag in our controls over advancing technology has been unreasonably accelerated in the atomic age.[1] This lag of social controls behind destructive power must be overcome if civilization is to survive or progress.

While a number of physical scientists have given attention to this question, in so far as social attitudes, human values, social change and international and intercultural relations are involved, this problem falls directly within the province of social science. In his book-length prize winning manuscript on *Social Science and the Atomic Crisis,* Hornell Hart goes so far as to say that "only a swift upsurge in the effectiveness of social science seems likely to bridge the otherwise fatal gap between destructive technology and social control."[2]

ATOMIC POWER AND THE PROBLEMS OF SOCIAL SCIENCE

But granted that the social sciences are able to discover workable solutions to the social problems of the atomic age and thereby bridge this gap of cultural lag, there is the strong possibility that our world leaders will not accept the findings or offerings of the social sciences. For social scientists cannot demonstrate the practicality of their research with anything like the conclusiveness that was demonstrated in New Mexico or at Hiroshima. The human element involved in social science and the attitudes accumulated over past decades toward the social sciences make it quite difficult even for educators and scientists to accept certain rather pointed conclusions of the social sciences.[3]

[1] In reporting for President Truman's Commission on Higher Education, George F. Zook warned that the gap between our scientific know-how and our social organizations for controlling our scientific knowledge has been growing steadily until now with the release of atomic energy the gap has become so wide as to produce a world-wide social crisis. See the report of President Truman's Commission on Higher Education, entitled *Higher Education for American Democracy,* (Washington, D. C.: Government Printing Office, 1947), pp. 21, 92, *passim.* See also L. Bryson, et al., *Conflicts of Power in Modern Culture.* New York: Harper and Brothers, 1947, pp. 574 ff.

[2] For a condensation of Hart's study which won him the Edward L. Bernays Atomic Energy Award for the outstanding action-related research contribution in a nation-wide contest among social scientists, see his "Social Science and the Atomic Crisis," *The Journal of Social Issues,* Supplement Series, No. 2, April, 1949.

[3] Reference is made to both controversial areas, such as predicting public opinion, elections, and the like, and such verified results as are available in studies of delinquency areas, marriage problems and prediction schedules, criminality and crime control techniques, population mobility, and related areas where empirically tested propositions are well-known.

How, then, can we expect our diplomats and politicians, who are less verse in the methods of objective, empirical study and more emotionally motivated, to *accept* the conclusions of the social scientist, let alone to enthusiastically *promote* the research which present problems would seem drastically to warrant? [4]

Atomic power presents serious problems to the social sciences. Somehow, social science must immediately discover ways of educating the public to its task. It must disseminate whatever facts it is able to discover. It must extend this research to wider horizons and to increasingly delimited areas of social life. It must establish, with convincing evidence, sufficient social controls to prevent excessive social disorganization, and somehow it must make possible the furtherance of its own search for more effective social controls. *It is as imperative that social science show men how to live together as it ever was that natural science reveal the secret of the atom.*

Now this is a mighty responsibility to be thrust upon the shoulders of such a youthful discipline. Social science has not matured even to the point where it can catch a glimpse of a formula for human relations akin to that which Einstein envisioned some 50 years ago. This sort of accomplishment takes time. But the demands for action are upon us.

If social scientists are honest with themselves, they must admit that their task is overwhelming and that they are ill-equipped for the job. For, even *before* the bursting of the first atomic bomb, the lag of the social sciences behind their older and more mature siblings was great enough to produce excessive disequilibrium in many phases of human life. *Now*, with the dawning of an atomic revolution, the social sciences find themselves lagging so far behind their sister sciences and faced with so monumental a task that failure seems imminent.

Why is this true? Why has social science continued to lag so far behind the natural sciences? In part, it is due to the variableness of the subject matter of social science. "Partly because social science has not given enough attention to scientific method. Partly because it has relied unduly on argument and personal opinion rather than on controlled experiment. Partly because the public has not understood and supported social science as a means for its own protection. Partly because legislators have not appropriated needed funds for social science research. Partly because there has been insufficient cooperation between social science and the ethical and spiritual forces of the world." [5]

Our problem, in the face of this situation, is whether social thought can achieve scientific maturity to *solve* the atomic crisis in somewhat the same manner as man's thinking in the fields of natural science achieved scientific power to *create* that crisis.[6]

While it is indeed easy to take a pessimistic view of the atomic crisis, if the social scientist is true to the tenets of his discipline, he has to be optimistic.

One reason for being optimistic is the indisputable fact that during the first decade of the Atomic Age several rather serious international entanglements and at least two major catastrophes have already been averted. There is no positive proof that these types of accommodative adjustments will not continue, thus giving us

[4] This problem of the "scientificness" of the social sciences and their authoritativeness has been faced by administrative officers of colleges, universities, foundations, and Congress and legislative committees. The matter was widely discussed and debated from 1945, when the original Magnuson and Kilgore Bills were introduced, to 1950, when the National Science Foundation Act became law. Even within the twenty-four members of the National Science Board, the social sciences have been viewed somewhat controversially and peripherally. See Harry Alpert's, "The Social Sciences and the National Science Foundation: 1945–1955," *American Sociological Review*, XX:653–57, December, 1955.

[5] Emory S. Bogardus, "Social Implications of Atomic Energy," *Sociology and Social Research*, XL:191 January-February, 1956.

[6] Hornell Hart, *op. cit.*, p. 14.

opportunity to work-out our problems and discover new insights into our basic problems of human relations.

A second reason for being optimistic stems from the progress that has been made within the past decade in social science research. To cite but a few examples, the social sciences have taken leading roles in the development of UNESCO's program; particularly impressive have been the studies of national tensions and intercultural relations. Research fostered by the Cross Cultural Survey Project at Yale University and the Research Project in Contemporary Cultures of Columbia University have had the specific objective of providing the scientific information on which can be based the international understandings prerequisite to world peace.

At long last, modest appropriations for social science research are being made by federal agencies and by special legislative acts. For example, since 1954 the National Science Foundation has fostered a limited social science program geared to projects utilizing scientific methods of research and related directly to the Federal Government's responsibilities for national welfare and national defense.[7] Furthermore, increasing numbers of research fellowships and grants of various dimensions are being made available through private foundations. Universities, industry, and state and local agencies are establishing social science research centers and increasingly expanding their research facilities and personnel in the area of human relations.

While a continued lag exists between the social and the natural sciences, increasing numbers of social scientists are moving rapidly away from the traditional armchair, philosophical types of speculative reporting and are adopting empirical research procedures. What this may mean within the foreseeable future may be surmised from the increasing stockpile of empirical research data from both individual social scientists and the increasing numbers of social science teams that are working in all parts of the world. To mention only a few illustrations here in the United States, attention should be called to such military research centers as the Human Resources Research Institutes at Maxwell and Randolph Air Force Bases; such governmental research programs as are being carried on through the Foreign Morale Analysis Division; such university research centers as the Institute for Research in Social Science of the University of North Carolina and the Russian Research Centers at Harvard and at Columbia; and the increasing number of cooperative research projects being carried on in the scientific study of economic behavior, public opinion and propaganda, group tensions and conflict, social change, social values, and the scientific study of social science theory and methodology.[8]

As the social scientist advances up the ladder of empirical research, what is he learning about the revolutionary effects of atomic energy upon modern society? What do the social sciences have to tell us about the bearing of atomic power upon the historic process?

A man would need to be committed to a philosophy of pessimism to believe that the in-

[7] Harry Alpert, *op. cit.*, pp. 556–63.

[8] Typical of some of the teamwork involved in these undertakings is the work of Samuel A. Stouffer and the field staffs of the National Opinion Research Center and the American Institute of Public Opinion Research in the studies of American attitudes toward *Communism, Conformity, and Civil Liberties: A Cross-Section of the Nation Speaks Its Mind.* (New York: Doubleday and Company, 1955), and a study of the Soviet social system (sponsored by the U. S. Air Force) by R. A. Bauer, Alex Inkeles, and Clyde Kluckhohn, *How the Soviet System Works: Cultural, Psychological and Social Themes.* (Cambridge: The Harvard University Press, 1956). Another illustration of this type of teamwork is afforded by the work of the Committee on Primary Records of the Division of Anthropology and Psychology of the National Research Council. This group is sponsoring a publication series on Microcards of personality materials collected in 70 non-Western societies. The first volume of the series included the materials of about 25 workers and consisted of approximately 4,000 pages of data. (For further information write The Microcard Foundation, Box 2145, Madison 5, Wisconsin.)

tensive preoccupation with atomic development which various nations are today displaying will result only in death and destruction, or, so far as atomic power goes, only in the blind alley of failure. It is not necessary to believe in atomic miracles. To believe that atomic power will find a place among the energy sources available to men is enough to commit oneself to the position that a chain of consequences will be established, the ultimate ramifications of which can now be seen hardly at all.[9]

CONSTRUCTIVE SOCIAL ASPECTS OF ATOMIC POWER

Varying degrees of optimism regarding the constructive uses of atomic energy have been expressed by both social and natural scientists. In this section of my paper I will attempt to summarize a few of these views.

Since technology and social institutions are interdependent, a change in technology tends to produce changes in social customs and institutions. We may therefore expect social changes wherever atomic energy is utilized. These changes, however, will probably not be dramatic. For, heretofore, any dramatic or profound modifications in the established institutions have required the influence of clusters of inventions and the passage of long enough periods of time for these inventions to be absorbed into the behavior patterns of a people.[10] Isard and Whitney remind us that the glib assumptions that developments of peacetime uses of nuclear energy will be automatic and that the mere availability of atomic power at relatively low cost will somehow produce the cornucopia for the most backward regions of the earth are unwarrantable assertions.[11]

Atomic energy supplies such an unlimited source of power and its development and utilization require such large-scale investments that it is highly improbable that individual enterprises will be any more able to develop it than individual scientists were able to discover it. To the extent that atomic power becomes a dominant economic force in the future, then it would appear that extremely large corporations or governmental bureaus or large organizations of one sort or another will control and operate the instruments of production.[12] This could eventually mean rather drastic changes in the economic structure of the United States and possibly other nations as well.[13]

[9] Walter Isard and Vincent Whitley, *Atomic Power: An Economic and Social Analysis.* New York: The Blakiston Company, 1952, p. 217.

[10] The most authentic works dealing with this aspect of technology and social change are William F. Ogburn, *Social Change* (New York: Viking Press, 1922); Bernhard J. Stern, "Resistance to the Adoption of Technological Innovations," in National Resources Committee, *Technological Trends and National Policy* (Washington: Government Printing Office, 1937); S. Lilley, *Men, Machines and History* (London: Cobbett Press, 1948), esp. ch. 11; Hornell Hart, *The Techniques of Social Progress* (New York: Henry Holt and Company, 1931); S. C. Gilfillan, *The Sociology of Invention* (Chicago: Follett Publishing Company, 1935), and Lewis Mumford, *Technics and Civilization* (New York: Harcourt, Brace and Company, 1934).

[11] Walter Isard and Vincent Whitney, *op. cit.*, pp. 140–41. See also P. M. S. Blackett, *Fear, War and the Bomb.* New York: Whittlesey House, McGraw-Hill Book Company, 1949, pp. 99–100.

[12] Robert M. Northrop, "The Changing Role of the Atomic Energy Commission in Atomic Power Development," *Law and Contemporary Problems.* XXII:14–37, Winter, 1956.

[13] Newman and Miller support this view with repeated comments similar to the following: "The [Atomic Energy] Act cuts more deeply into the area traditionally reserved to private business in our system than any ever passed in time of peace. In fact, it does nothing less than establish in the midst of our privately controlled economy a socialist island with undefined and possibly expanding frontiers. Into a system that was happily being reclaimed for free enterprise in the postwar period the Act deposited a large, portentous, alien, and unassimilable lump. What the outgrowth of interaction between these opposing elements is likely to be Congress did not even discuss. . . . It may well be that the existing form of our economic order is no better able to contain atomic energy than is the present international order and that, in fact, the force will produce political changes in the international arrangements of our society as momentous as those that will almost certainly occur in our external relations." . . . These authors go on to say that "the policies followed by the Commission in exercising these powers must have a direct and powerful impact on many important aspects of our national life. They will affect not only our military security but our foreign policy, the value of existing capital investments,

Unless atomic power is replaced by the development of solar energy, its constructive uses may, in time, be expected to spread to most of the areas of the earth, minimizing poverty and disease. However, any rapid and marked increases in the levels of living of the various peoples of the world, and especially of those whose current levels are lowest, is unlikely to result from the advent of atomic power alone. Yet the indirect effects of atomic power upon the economic system may prove to be of greater consequence than were those brought about by the use of the internal combustion engine or the radio. The use of new materials produced by transmutation promises to supply us with heat and power available in large quantities wherever needed and thus to open new economic frontiers. While much of the research is classified, we may be sure that new advances in medicine, in industry, and in science are rapidly being made—all of which indicate the magnitude of the indirect effects of atomic power.[14]

Extended constructive uses of atomic energy will tend to conserve human energy and hence will mean shorter working days, longer periods of leisure, and eventually a shortening of the working years. This would seem to suggest rising standards of living, expanded educational facilities, the development of the creative arts, and perhaps a marked decline in death rates.

Another result of the extended use of atomic energy will be swifter and more economical modes of transportation and an increase in travel opportunities. (We may reasonably expect nuclear-driven ships in the near future, in spite of recent discoveries of defects in our nuclear-driven submarines, but until the shielding problem has been solved we will not have nuclear-driven automobiles.)

For a number of years, atomic piles with uranium bases for producing radioisotopes have been used in hospitals and research centers. "The implication of isotope developments is that many diseases now baffling to medical science will be conquered, and the health of people generally will take on new dimensions." [15]

Finally, atomic power supplies us with the type of weapons which make war intolerable, thus opening the way for an international organization to prevent war and to effect a mutual sharing of the benefits of atomic development. The progress that is being made in most every phase of atomic research indicates that in the long-run the full potential of atomic power can be realized only under conditions of international accord. Hence, the most significant implication of atomic power is that man is being forced along a difficult road to greater humanity. He is being forced to remodel his world, while trying better to understand what is happening to it.[16]

ATOMIC POWER AND THE HISTORIC PROCESS

For more than 100 years social scientists have been studying the dynamics of social life. Most of these students are agreed

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the structure of industry, and the level of prices and employment—in the end, the structure of society itself." James R. Newman and Byron S. Miller, *The Control of Atomic Energy*. New York: McGraw-Hill Book Company, 1948, pp. 19, 21, *passim*. See also Aaron Levenstein's *The Atomic Age*, pp. 18–23.

[14] A most optimistic view is taken by Aaron Levenstein in his *The Atomic Age*, p. 18 when he says: "This is the kind of world on whose threshold we stand—a world in which no country need think of itself as over-populated, in which no soil is too poor to feed its husbandmen, in which no urban citizen is condemned to slum-dwelling, in which no child would carry the grime of poverty on his face and soul." This view is also shared by Emory S. Bogardus in his "Constructive Social Aspects of Atomic Energy," *Sociology and Social Research*, 40:342–43, May-June, 1956. A more conservative view and one which is more definitely supported by established principles of social sciencce is advocated by Isard and Whitney, *op. cit.*, pp. 219–220, *passim* and S. C. Rothman, *Constructive Uses of Atomic Energy*. New York: Harper and Brothers, 1949, chs. 2, 8.

[15] Emory S. Bogardus, "Constructive Social Aspects of Atomic Energy," *Sociology and Social Research*, XL:346, May-June, 1956.

[16] S. C. Rothmann, *Constructive Uses of Atomic Energy*. New York: Harper and Brothers, 1949, pp. 24, *passim*.

that technology and other phases of culture have been changing at accelerated rates. This principle of accelerating social change has been confirmed by detailed mathematical analyses of such trends as the power to kill, speeds of travel, real income, expectation of life, the number of college graduates, and various types of other social series. These findings have been summarized by Hornell Hart into a broad fundamental hypothesis, which he states as follows:

> Throughout the entire sweep of history and prehistory, the power of human beings to achieve their basic purposes has been increasing at accelerating speed, with local and temporary stagnations and setbacks. This long-run acceleration has taken place through series of logistic, and also of continuously accelerating surges, having higher and higher rates of increase.[17]

These surges or accelerated rates of change are brought on by discoveries and inventions, that is, by new combinations of existing elements. More specifically, the speed of social change tends to vary directly with (1) the geometrical increase in the number of cultural elements to be combined, (2) the increasing potential of available elements to add to human achievements, and (3) the development and accelerating improvement of the scientific method of making inventions and discoveries.[18]

If the general conclusions of our authorities on social change are correct, and if we are not altogether deceived about the nature and potentialities of atomic power, then we are safe in advancing the following hypothesis: The revolutionary effects of atomic power upon modern civilization will vary directly and at an increasingly accelerated rate with the number and efficiency of the atomic functions or operations performed in modern society. Stated somewhat differently, the social implications of atomic power are so broad and its derivative effects so inclusive that we may expect increasingly accelerated changes in every area of life in which atomic energy in any form is applied or brought into use. Of course, the revolutionary trend of such changes will necessarily vary directly with the degree of intensity of the application of atomic energy to a given area of socio-economic and/or political life. This general hypothesis would seem to hold whether the application is in a destructive form, such as an atomic bomb, or in a constructive manner, such as in the development of power plants, the sterilization processes, or in opening up new avenues of cancer therapy.

The over-all effect of the type of social and cultural acceleration which atomic power is fostering and will continue to promote is undoubtedly changing drastically the course of human history. A rapid glance into the past tells us that discoveries and inventions have been crucial in changing both the basic motives of men and character of civilizations as well.

The vision of a Jew, about to sacrifice his son, released a pang of fear, bringing faith, hope and unity where there was only awe. The birth of a Carpenter's son in a cow stall freed man's spirit from the shackles of legalism and kindled a flame of brotherliness that flickers on. The tap, tap, tap of a priest's hammer nailing some propositions on a church door jarred loose the mind of man from the tongs held in the hands of fanatic guardians of the holy light. The belch of black smoke from an elongated pipe eventually straightened the aching back of the warm, neighborly clodhopper and sat him down as a cog in the factory wheel. A stock market crash and a New Deal thwarted man's initiative and taught him to believe in Santa Claus and to take refuge in Uncle Sam's palace.

Yes, each of these symbolic happenings brought a new motive for living, a new hope or fear, and a new way of life. One turned man's fears of the mysteries of the world and his vision of himself into a confidence and realization of God. Another turned man's plea for justice into a fellowship of love. And another revealed to man

[17] Hornell Hart, *op. cit.*, p. 9.
[18] *Ibid.*, p. 10.

his potentialities and his justification by faith. But other events taught man that his own initiative and his faith in himself were not enough. He discovered that not even the machine, privately owned and operated, could prevent bank failure and depression. And still other events have taught him that a great leviathan—atomic energy—is looming upon the horizon, driving man, partly through fear and partly through hope, into a new way of life.

One of the greatest effects of atomic power in our time is its forcing of human society into new patterns of adjustment and growth. The need for human growth to meet the responsibility of atomic power is the basis of Norman Cousins' timely statement that "modern man is obsolete."

As free enterprise and competitive struggle and personalized conflicts have so strongly motivated and dominated modern society for the past several centuries, so must *increasing degrees of cooperation* between diverse groups spread over ever-larger areas, becoming the dominant pattern of relationships in the atomic age. Since this is so obvious, both from the viewpoint of folk knowledge and from the principles and laws of social science, the atomic age challenges social science to discover ways to extend cooperation at all levels and in all divisions of our society. For the one thing that the society of an atomic age cannot permit is "the development of antagonisms between groups that will prevent effective cooperation." [19] If our civilization is to survive at the atomic level, the course of history must be changed from individualized, dominating, antagonistic patterns of behavior to more brotherly, cooperative, and loving relationships.

In the second place, atomic power is teaching us that ours is a most complex world. To adjust in the modern world, and especially in an atomic age, demands that we have *increased training and education*. Technical education is not sufficient. Of greater importance is more general education, more education for leadership, and more education in those areas of moral and spiritual values that will enable us to be more tolerant and understanding, more loving and charitable, and more brotherly. The atomic age challenges the social sciences to provide efficient leadership. Social science must determine under what types of social structures the maximum degree of effective, humanizing, technical and leadership education can be fostered.

Finally, and perhaps most remarkable of all, atomic power is producing an *increasing concern among men that their activities shall contribute to the welfare of society*. We seemingly have reached a turning point in history, where service to others and not to ourselves alone is a prerequisite not simply for happiness and the good life but for survival. It is the task of social science to determine under what conditions may the maximum services be rendered to the greatest number of people over the longest span of time at the least expense of time and energy. This task can be realized only through the type of scientific studies of social values, methods of social control and intercultural interaction that will enable us to realize who is to do what, under what circumstances, and to what serviceable ends.

If man is not willing to accept voluntarily the moral and religious teachings of love and brotherhood, he cannot long fail to see that the release of atomic energy is another step in the steady progression of science that is compelling man to become human. We are nearing that turn in the course of history, if we are not already well into it, where we must think of others or perish. If we will let ourselves grow in the direction which the forces of our present age seem to be compelling us, "the civilization of the atomic age promises to be the richest that history has known, not only with regard to material bounty, but also in its cultivation and appreciation of the truest human values." [20]

[19] S. C. Rothmann, *op. cit.*, p. 20.

[20] *Ibid.*, p. 23.

THE ROLE OF THE PROFESSIONAL SCIENCE EDUCATOR IN THE PRESENT MANPOWER SHORTAGE *

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There has never been a period in the history of education in America when science in general, and science education in particular, have occupied such an important position in the public eye. In fact, it is probably true that no single curriculum area has ever commanded so much attention as is currently true of the subject which we represent.

In the highest places of Government, industry, and education men have given voice to the crucial need for increasing the present supply of scientific personnel and in some instances have made rather dire predictions for the future if this is not achieved. In his message to the Congress on the economic problems of the Nation, President Eisenhower called attention to the critical shortages of scientific manpower and singled out science teaching in the secondary schools and colleges of America as one of the vital factors in the future well-being of our Nation. One prominent educator has said rather pointedly, that if the cold war is lost it will be in the science and mathematics classrooms of the American high schools.

There can be little doubt but that shortages of technically trained manpower do exist. We know that science and mathematics teachers are in short supply. However, it seems equally true that there is some hysteria in the present situation as witnessed by the many nostrums which have been put forward as panacea for our current difficulties. It is very essential for us as professional science educators, to be objective and try to appraise the situation as it actually exists and not to be swept into unreasoned temporary measures merely by the loudness or the number of the voices that are raised.

As a result of all the current publicity and attention that is being directed toward science teaching, the total picture of our professional area has been thrown into the limelight and stands out in bold relief from the other areas of the high school curriculum. Recently, I have had an opportunity to talk with professional people in several State departments of education, with people engaged in teacher training, as well as with many teachers and supervisors of science who work at the grass-roots level. Everywhere the story is the same. They are aware of the problem, deeply concerned, and unable to do very much about it. They are feeling the pinch of the shortage of science and mathematics teachers and are trying to cope with it often through temporary and unsatisfactory expedients. These conditions seem to be general in so far as my experience has revealed them.

It is most fitting at this time that we as professional science educators examine what seem to be the real facts in the manpower shortage and attempt to see their implications for us. We must know our strengths and weaknesses, our present capacities and our potentials for dealing with the problems. Above all we must not be complacent but must assume full leadership with a program of action directed toward an alleviation of present shortages and the ultimate solution of the problem for the years ahead.

In attempting to define the role of the professional science educator in relation to the manpower shortage it will be helpful to review briefly the situaiton as it now exists, to extrapolate the available data and to see what the problems may be as we

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look ahead, to examine certain measures already taken and to project our thinking into further steps which may be pursued.

As we look at the present problem of shortage of scientific personnel we find that it is not in any sense a local problem. In fact data are available to indicate that the problem is worldwide except for one or two of the countries in Europe. In some of the less advanced countries of Southeast Asia, for example, where they are moving rapidly from an agrarian way of life to a technological economy, the shortage of trained science personnel and science teachers is even more acute than in some of the other places. The problem in these nations is even more critical than we can imagine for it is complicated by other factors which do not exist in the more technically advanced nations. This example may suffice. In some of these areas there are no resources of fossil fuel. Heat for domestic purposes is supplied by the burning of wood, or charcoal, or even refuse. Industrial power is often supplied by the burning of wood under the boilers which supply steam.

It has been predicted by reliable authorities that these will be among the first countries to adopt atomic energy for power. If this comes about there will be an even greater demand on the technically trained manpower than at present. Teaching will attract fewer and fewer students, because in these areas the salary differential of the teacher and the engineer, for example, is greater than in other countries.

The above condition could mean a cataclysmic blow. For the teacher must be the one who will not only provide training for the manpower reservoir but who must bear the burden of training the people of this and the next generation for the change from an agricultural economy to that of an atomic age. We only need remember the economic displacements which resulted from the introduction of steam power in Europe in the eighteenth century to see the possible results when atomic energy is suddenly thrust into a Nation which is unprepared. Truly science teaching takes on a new significance.

The very fact that the problem is so widespread would seem to indicate that the present crucial situation here in America cannot, as some critics have stated, be altogether due to the lack of good science teaching in secondary schools. Perhaps, this is one factor, but in the larger situation it would seem more reasonable to look for other causes, such as the increasing demands placed upon an economy which is so intensely influenced by the rapid advances in science and technology.

Whether we are aware of it or not, we as professional science educators are, together with our colleagues in the colleges and universities, engaged in a competition of survival with our counterparts in the Iron Curtain countries. If our way of life is to survive, it will be largely the result of the fact that we have won the battle in our classrooms and laboratories. Judging only on the basis of numbers, our present position in the race is not an enviable one. In 1950, in the U.S.S.R. 28,000 engineers were graduated. Last year this number was increased to over 50,000. Over the same period the Soviets have also made percentage gains in trained research personnel and in industrial technologists. Do the figures show a similar gain in America? The answer must be an emphatic no. In fact over the same five-year period our production of engineers has declined from 53,000 in 1950 to 23,000 in 1955. For the years just ahead it appears that the production of engineers will increase to about 30,000 per year in 1956, 37,000 in 1958, and to about 39,000 by 1959.

During the Korean War the United States Bureau of Labor Statistics estimated that there would be a need of a minimum of 30,000 engineers annually. Since that time the advances on all scientific fronts have been so rapid that today a conservative estimate would be 40,000.

Recently the U. S. Manpower Commission estimated that there were 7,500 positions vacant requiring research scientists

and more than 15,000 unmanned engineering jobs. The Atomic Energy Commission in a statement issued recently has predicted that this field alone will be able to absorb at least 15,000 technically trained persons in the next decade. To confirm these needs which are immediate one has only to look at the "Help Wanted" pages of any metropolitan newspaper.

If the demand for engineers and research workers were to remain stable, the present supply would be greatly insufficient. It has been stated on reliable authority that industry will need 6,000 more such personnel in 1956 than was true in 1954. The statistics also show drastic shortages in other fields—shortages of chemists, doctors, nurses, medical technicians, high level skilled workers in technological industry, and others. It has been predicted that there will be a doctor shortage of from 30,000 to 50,000, registered nurses 50,000, and teachers 293,000 by 1960.

Let us examine the picture as it pertains to science teachers. The National Education Association estimates that there are about 38 million pupils enrolled in the schools of the United States at the present time. By 1960 it is predicted that the numbers will increase to around 46 million. The closest estimates available indicate that about 60,000 teachers are now teaching some science and about half of these are full-time. If we extrapolate the presently available data it seems that by 1960 a conservative estimate would place the needs for full and part-time science teachers at around 80,000. This would include an estimated 8,000 to 10,000 teachers for annual replacement and 1,000 for new teaching jobs created by increasing enrollments.

If we may place some confidence in these figures, it would seem that our profession will be faced by a crucial shortage unless ways are found to remedy the situation in the near future. We must also be aware of the fact that the efforts of industry to entice people away from teaching is not likely to lessen in the foreseeable future. Faced by these conditions there is a grave need for some clear thinking and planning by the science education fraternity and more important a need for some bold and vigorous policy declarations and the assumption of leadership in attempting to set forces in motion to avert the almost inevitable results. Above all, we must not be complacent to the point where others will step in and assume the leadership which is rightfully ours.

The facts on present high school enrollments in science as they relate to the manpower shortage while not as encouraging as we would hope for are not as bad as they have been pictured by some. One conclusion which stands preeminent from these data is that if we are to have an adequate reservoir of manpower now and for the future, young people in increasing numbers must take science courses in high school, go on to advanced work in college and then on into careers in science and mathematics. This appears to me to be inescapable and it places a heavy responsibility on us as professional science educators.

Training and understanding in the basic sciences and in mathematics are essential to successful work in technical fields. Today young people are avoiding these courses which would provide the competencies needed. A study conducted in 1955 indicates that 88 per cent of all the schools in the study that had pupils in the 10th grade offered biology and that biology was offered less frequently in the small 4-year high schools than any other type of school. About one-half of the schools in the study offered physics and/or chemistry. Some schools alternated the offering of physics and chemistry to combined classes of 11th and 12th grade students. The study also revealed that 23 per cent of the schools offered neither physics nor chemistry in the fall of 1954. In fact, nearly one-half of the undivided 5- or 6-year high schools failed to offer either physics or chemistry. If opportunities are not given for pupils

to take science, many will fail to develop their potentialities.

The most recent data available on actual enrollments in high school science show that in 1954–1955 the number of pupils enrolled in biology was equal to 72.4 per cent of the total number of pupils in the 10th grade. The number of pupils enrolled in chemistry in all schools in the study was equal to 31.9 per cent of the pupils in the 11th grade. The enrollment in physics was equal to 23.5 per cent of the number of pupils in the 12th grade. In numbers this would mean about 1,293,000 pupils enrolled in biology; 482,700 pupils in chemistry; and, about 302,000 enrolled in physics in the public schools of the country in the fall of 1954.

These data reveal a condition of enrollment in science courses which while not what we would wish them to be nor perhaps anywhere commensurate with the need and demand, are by no means as dire as the statistics quoted by some would seem to indicate.

Recently several prominent speakers have pointed out that in 1890, 22.8 per cent of the pupils in high school took physics while in 1949 only 5.4 per cent was enrolled. It is unfortunate that at the same time these speakers failed to point out that 22.8 per cent of the high school population in 1890 represented an enrollment of 46,184 students while 5.4 per cent in 1948–1949 represented 291,473 students.

On many fronts, responsible agencies have become aware of the problems of manpower shortage and a considerable number of programs designed to improve the situation are either underway or in the planning stages. It is not essential for purposes of this paper to review each of these efforts in detail since literature on them is available. Only a few of the programs will be mentioned.

The National Science Foundation, an agency of the United States Government, will sponsor twenty institutes this summer for college and high school teachers of mathematics and science. In addition, institutes for the academic year of 1956-1957, will be held at Oklohoma A and M College and at the University of Wisconsin.

Under the sponsorship of industry and other agencies there are more than twenty other summer institutes planned. The Shell Petroleum Company is the sponsor of two programs planned for the school year of 1956–57, one at Stanford University and the other at Cornell University. It has been estimated that between fifteen hundred and two thousand teachers will be reached through the institutes mentioned.

The Mathematical Association of America has instituted a program of visiting lecturers. Outstanding scholars in mathematics are sent out to small colleges for a series of lectures and conferences. This provides an opportunity for the staff and major students of small colleges to come in contact with productive and creative mathematicians.

The American Association for the Advancement of Science has established a program for the improvement of science and mathematics teaching. Under the able leadership of Dr. John Mayor, this program has already made considerable headway. Beginning in the next school year they will carry on a project cooperatively with four selected States. Two science supervisors will be placed in each State to work closely with the local colleges and high schools and with the State Departments of Education in an effort to improve science teaching through better supervisory services.

Under the sponsorship of the Future Scientists of America Foundation of NSTA thirty-eight university and other research laboratories are this year conducting a program of Summer Research Assistantships for high school teachers of general science, biology, chemistry, and physics. These assistants will spend full or part-time through the summer assisting in the development of individual projects. Close association with research people will help bring the teachers up-to-date on new developments in science,

let them become acquainted with some research methods and generate suggestions for improving science teaching at all levels. The National Science Teacher's Association is continuing its excellent program in conjunction with the American Metals Association, is again conducting a Summer Workshop on the Pacific Coast under a grant from the Crown-Zellerbach Foundation, and is setting up a new Summer Institute for Chemistry Teachers from Wisconsin which will be held at Lawrence College under a grant from the Marathon Paper Corporation.

In October of last year more than one hundred fifty science teachers from the states surrounding Washington, D. C. were brought together at the National Cancer Institute for a unique workshop. These teachers had an opportunity to see research workers in several fields at work in their laboratories. These scientists had spent many weeks preparing practical demonstrations and experiments which these teachers could take back and repeat in their classes. These experimental materials have been mimeographed and are available from the National Cancer Institute. They have also prepared a guide showing how a similar conference can be set up in almost any city in the country. The National Cancer Institute has also given a substantial grant to the National Science Teachers Association to be used for a science teachers award program. This will be known as the STAR program for the "science teachers achievement recognition."

The Oak Ridge Institute of Nuclear Studies, in addition to conducting one of the summer institute programs under the sponsorship of the National Science Foundation, is setting up an interesting project of roving mobile units for the improvement of high school science teaching. Eight science teachers are now being selected for summer training at the Oak Ridge Institute. At the close of the training period each one will be given a station wagon that is fully equipped with materials for science demonstrations in high school science. The demonstrators will be sent out over the country on previously determined schedules. They will go into communities and attempt to help the teachers by instructing them in such things as improved methods of teaching, making simple equipment, etc.

The National Research Council has set up a pilot project in the schools of Arlington, Virginia which enlists the Parent-Teacher Association in securing funds to provide scholarships for teachers of science and mathematics in that school system. This enables teachers to be freed from the necessity of securing summer employment and to attend selected universities that are cooperating in the project.

This summary by no means completely covers all of the projects and activities that are presently going on in an effort to alleviate the manpower shortage. It does testify to the widespread interest in the problem and that steps are being taken on many fronts to cope with it.

It seems reasonable to assume from the foregoing discussion that the science teaching profession is facing rather critical years ahead, and that there are now underway several programs designed to alleviate the manpower shortage. However, it should be recognized that the most important factor in correcting the shortage is more and better science teachers and students in the classrooms. The condition will be improved only as more young people become genuinely interested in science, take courses in science, and then follow through into careers in its various fields. It is primarily a problem of the science teacher and the science classroom.

With your permission I would like to present a few suggestions which seem to me to be pertinent for professional science educators as we face the problem of providing a larger reservoir of technically trained manpower now and for the future.

1. *Assuming leadership in a vigorous program of patterned or planned research in science teaching.*

We as a group represent that segment of science education that is primarily con-

cerned with research. Agencies and institutions already engaged in programs designed to alleviate the manpower shortage are rightfully looking to us for the answers to many questions which they are asking. Thus far, ours is a record of fine achievement in research in science education. Answers have been found for many basic questions.

A casual review of the literature over the past thirty years will show that some of these questions were answered by patterned and planned research programs which have resulted in concerted studies of basic problems. Mention should be made of the research on vocabulary and science principles under Dr. Curtis at Michigan; on basic science concepts, under Dr. Powers at Columbia; and on problem solving under Drs. Pieper and Barnard at New York University.

A few days ago I received a letter from a venerable member of this organization in which he lamented the verbalism and trivia in much of the current research in science education and made a plea for more planning and group attack upon basic problems as yet unanswered. I mention this only as one opinion from one of our colleagues. Do we need to search out the essential questions where answers are needed and then collect our resources in a serious attack upon them?

2. *Assuming leadership in curriculum revision in science education.*

It has been my privilege during the past few years to go into schools and to attend meetings of science teachers in several parts of the world. One observation in particular has made a deep impression upon me, and that was the amount of science training that boys and girls of sixteen and eighteen years acquire in the schools of Europe, and also in other parts of the world. I am fully aware that in general these young people represent a selected group but the fact remains that they emerge from their secondary schools with training which approximates our freshman and sophomore college levels.

I am equally aware of the fact that in a democracy we must have a broader base of educational opportunity and must train larger numbers. I often wonder if we could not do much more with our better students if our science instruction were pitched to a higher level, and if our curriculum materials were better placed and integrated so that students would not lose so much time in repetition of things already taught at lower levels. Much study and research is needed to set our science curriculum in order.

3. *Assuming leadership in a program to improve the training of science teachers.*

In any approach to this significant aspect of our work as science educators we must first pay tribute to those teachers who have received their training in an earlier day. To these we are largely indebted for the technological progress that has been made up to now. It was in their classes that the present generation of scientists received their inspiration and training. To them we must say *"well done."* But it would be folly for us to be complacent and satisfied. We know that if the future of our way of life is to be assured, teacher education in science must move forward as a sound base for the continued achievement of young people who will go through our schools.

There is another urgent demand which must be faced by those in whose hands the training of future science teachers rests. With the increasing influence of science in the lives of lay people the science teacher of tomorrow must have a broad understanding of the impact of science on the economic and social patterns of our country. He must be trained so that he can participate with sympathy and with understanding in providing the broad pattern of education needed by those young people who will not become scientists and technicians.

Living in the world of tomorrow perhaps will be easier and simpler in terms of the outlay of physical energy. However, with the oncoming of automation and the myriad of new developments in other lines, living effectively on an intellectual level may be

fraught with pitfalls as yet unseen. In a milieu such as we can seen in general outline, it would seem that young people are going to have a great need for training in those mental habits and skills that will enable them to solve their perplexities with efficiency.

It is an old truism that teachers tend to teach as they were taught. If there is an element of truth in this then we as professional educators must face the task of providing a curriculum in teacher training that will be so rich in problem solving experiences that young people will go out to teach, so well grounded in its attitudes and habits that they will pass them along to their students. It would be my hope that the professional educators responsible for teacher training for today and tomorrow would do as thorough a job in inculcating the inductive approach to problems as those of my day did in passing along the lecture method.

4. *Assuming leadership in improving the quality of science teaching.*

Rightly or wrongly some of the blame for the present critical conditions in scientific manpower has been attributed to the lack of good science teaching. Unfortunately, data are not now available to give us a clear picture of the qualifications of science teachers as a whole. Nor do we know much about those from other fields who have been forced into science teaching because of the inadequate supply. A study that will in part answer these questions is now being explored at the U. S. Office of Education.

We do know that there is a great attrition in enrollment between the junior high school science classes and the specialized sciences in the later years. We also know that many young people are avoiding science and mathematics studies in the senior high school. How much of this may be attributed to uninspired and uninteresting science teaching in those years when our young people are forming their abiding interests and making decisions on careers, is not known. Perhaps we would attract a greater number of young people of talent toward science and mathematics classes if we were to make sure that our best teachers were assigned to teach and supervise at the junior high school level. This might be one way to prevent the great waste of potiential talent that we do not now have an opportunity to train.

5. *Assuming leadership in formulating and implementing a vigorous program for science education.*

It would seem that a technical manpower shortage is going to be with us for many years. We need to view it objectively and calmly, and apart from the hysteria that has seemed to characterize some of the newspaper and magazine accounts. We need to see the problem clearly, and then put our best brains to work to discover the most promising methods of solving the problem.

The programs that are now under way to alleviate the shortages should be critically evaluated in terms of yield and then modified in the light of the findings. If it is reasonable to assume that one major factor in the ultimate solution is to attract more and better young people into well taught science classes, then we must reason that the science teacher in his laboratory and classroom is a key figure. Thus it would seem that in the final analysis the problem is an educational one to be solved in the area where the professional science educator has his special competency.

If these things be true, then the science educators must assume vigorous leadership along all avenues which may lead to the solution of the problem. Science education must come forth with a program which can gain the respect of our colleagues in the pure sciences on the one hand, and those agencies who must depend upon technically trained manpower on the other. Unless we can measure up to this leadership which is rightfully ours, we are jeopardizing the future of the profession of science education.

THE SCIENTIFIC MANPOWER PROBLEM AND THE PROGRAM AT TEACHERS COLLEGE, COLUMBIA UNIVERSITY

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There are five principal employers of scientific manpower in the United States today. They are industry, government, the armed forces, agriculture, and education. The relative demand placed upon the scientific manpower supply varies from time to time, depending upon the state of production, the requirements of national defense, the student population of schools and colleges, and other factors. But the long-term trend, spearheaded by industrial expansion, has been steadily on the upgrade, paralleling increased use of metals, plastics and power. The relatively small band of scientists and technologists who were engaged in industry at the turn of the century—some 100,000—has become an army of over a million, and from many sources we hear the warning that the available supply of such personnel is not adequate to meet current demands of industry alone, to say nothing about the demands established by other facets of our culture. This growing lack of scientific brainpower is a very real threat to our way of life, and there is little indication that, if left to its own devices, the existing state of affairs will take a turn for the better in the near future. Yet the necessity of maintaining an adequate scientific manpower supply is virtually self-evident. As the National Manpower Council[1] comments, "This nation's economic and social well-being and its continued progress depend to a striking degree upon a small group of men and women who work in scientific and professional fields."

For purposes of this discourse we may define scientific manpower as consisting of scientists and technologists. Knapp and Goodrich[2] have described the professional scientist as a person who has received the Ph.D. degree in biology, chemistry, physics, geology, astronomy, mathematics, or psychology. When we speak of technologists our thought naturally turns to engineers. But although the leaders in research, scientific enterprise and technological development undoubtedly will come disproportionately from the ranks of skilled professional scientists and engineers, these are not the only classes of personnel about which we need to feel concern. In addition, there must be a host of assistants and technicians, possessing various degrees of scientific training, whose work facilitates and implements scientific discovery and technological applications. In a broader sense, therefore, scientific manpower consists of all personnel who make active contribution, however small, to the scientific endeavors of our civilization.

In the cross-currents of modern world politics, all nations have been alerted to the necessity for scientific and technological progress. It has been pointed out in several recent publications that the educational program of the Soviet Union and its satellite nations incorporates an emphasis upon science in elementary and secondary schools far in excess of our own, and that their technical schools of university rank and intermediate technical schools are engaged in the training of scientists, engineers and technicians on a scale that we do not approach in the United States today. In speaking of the U.S.S.R., Lewis L. Strauss[3] indicates that "Today their

[1] Graduate School of Business, Columbia University. *A Report on the National Manpower Council,* 1954, pp. 13–14.

[2] R. H. Knapp and H. B. Goodrich, *Origins of American Scientists,* University of Chicago Press, 1952.

[3] Lewis L. Strauss and Hyman G. Rickover, *Freedoms Need for Trained Men,* Thomas Alva Edison Foundation, West Orange, New Jersey, December, 1955, p. 5.

technical schools and universities are turning out scientists and engineers who are well-trained and highly competent." Then Strauss goes on to say that "The Soviet challenge is not one of technological quality so much as of numbers." What this may mean for the future is not altogether clear, although lessons of the past should warn us against any assumption that we do or shall possess an overall superiority in weapons or the capacity to produce materials, whether we think of these as deterrents to aggression or the potential for defense.

The foregoing analysis of the situation has also been commented upon by Professor S. Zuckerman,[4] who pointed out that Great Britain may also have a scientific manpower problem, and went on to say that ". . . the nations of the world are now engaged in a race to transform themselves scientifically . . . because of the realization that in a competitive world science and technology provide the key to higher material standards of living and form the foundations of economic and military power."

Yet when we look at the American record of college enrollment in the physical sciences we are likely to conclude that the figures seem more appropriate for 1900 than for mid-century. In the academic year 1953–1954 our colleges and universities graduated nearly 300,000 students with Bachelor's or first professional degrees, of whom only 1.9 per cent had majors in chemistry, and about 0.7 per cent had majors in physics.[5] Moreover, in the years between 1950 and 1954, the number of graduates in the natural sciences decreased about 51 per cent, and the number of engineering graduates decreased 58 per cent. It should be noted, of course, that in 1950 many returning veterans of World War II were still enrolled in colleges, and that total college graduates decreased by some 34 per cent during the following four years. It is evident, however, that the decline in science and engineering graduates has been more pronounced than that of the general college population.

So inevitably the question arises: Why does the aforementioned condition exist? We live in a society broadly marked by the works of science, and we are aware that many of our young people exhibit more than passing interest in various mass communication media in which science and science fiction are a conspicuous part of the offering. When we examine the want ad columns of our large newspapers we must be struck by the pressing demand for trained scientists and engineers. The demand exists, but the supply does not materialize, and the seeming paradox may not be rationalized until we turn to an examination of what has happened in our secondary schools. It is in the working of the secondary-school program of science and mathematics that we may find a reasonable explanation.

Figures made available by the United States Office of Education[6] show the trend of student enrollment in eleventh and twelfth grade physics and chemistry, and these figures are too well known to require repetition here. They show a gradual but steady decline in the popularity of the physics course during the past thirty years and indicate the 1952 enrollment in high school chemistry as 7.6 per cent of the school population. It is, in fact, apparent that the vast majority of senior high-school students receive no training in the physical sciences. Moreover, since colleges have progressively abandoned the requirement that entering students must have had a high school laboratory course in science, more and more schools—and especially

[4] S. S. Zuckerman, "Scientists and Technologists in the U.S.S.R., American and British Output Left Behind," *London Times Educational Supplement*, December 30, 1955.

[5] Based upon figures of the United States Office of Education as quoted in the *World Almanac and Book of Facts*, 1956, p. 480.

[6] As in: Federal Security Agency, Office of Education, *The Teaching of Science in Public High Schools*, Bulletin 1950, No. 9, and others.

the small but numerous high schools spread out across the nation—have reduced or eliminated their offering in physics and chemistry. Johnson [7] reported that in the case of a sample of high schools for the fall term of 1947–1948, only 49.4 per cent had operating courses in chemistry and 47.8 per cent had operating courses in physics. Meanwhile, according to the Annual Report of the Educational Testing Service,[8] only 25 per cent of our current high-school population studies algebra, and 12 per cent studies geometry.

When we seek an underlying cause of this retreat from physical science and mathematics we have recourse to opinion only, but we soon come to the conclusion that more than one influence is at work. The Annual Report of the Educational Testing Service,[9] for example, cites the argument that in the modern high school "less demanding courses offered for non-college or weaker students attract the college-oriented and able students as well." The result seems to be that many students tend to avoid courses that are supposed to be more difficult, including mathematics and the physical sciences. Such a conclusion gains support from the well-known fact that the high-school population has changed greatly during the present century; sixty years ago it was a rather select group, but today it represents virtually a cross-section of the population as a whole. Naturally enough, there have been pressures from various sources, including the parents of students, to adjust the curriculum to the widened range of student ability. This has resulted in a diversified offering of courses from which students may elect, and perhaps a disproportionate amount of attention to the students whose progress tends to be retarded. In the meantime, it seems possible that the more gifted students are often "lost in the shuffle," that "following the line of least resistance" they take courses which present no real challenge to their abilities, and that they are not given full opportunity to develop their potentialities.

But the high-school curriculum is not the whole story by any means. We must also face the fact that in recent years the supply of new secondary-school teachers of physics and chemistry has dwindled. Good teachers of any subject are scarce enough, but in the case of physics and chemistry the shortage has been especially marked. It is variously stated that the country needs from 5,000 to 7,000 new high-school science teachers each year to maintain existing programs. In 1950 some 9,096 individuals completed programs which qualified them as high-school science teachers, and this rate of production might just about have met the need, provided you ignore any question of quality, for studies have shown that about half of the people so-trained actually go on the following year to careers in teaching. However, in 1955 the comparable group of qualified graduates was but 3,978 individuals, and this would not have met the need if all of them had accepted school appointments.[10] One observable result has been a rash of emergency or special licensing, a practice which scarcely will serve to produce a corps of good or superior teachers. As the Report of the Educational Testing Service [11] indicates: "This fall, six-thousand new high-school science teachers were needed, and only a third of this number were available. Two-thirds of the vacan-

[7] Philip G. Johnson, "Occurrence of Science Courses in American High Schools," *Bulletin of the National Association of Secondary School Principals*, January, 1953, p. 2.

[8] Educational Testing Service, *Annual Report to the Board of Trustees*, 1954–1955, p. 15 (article by Henry Chauncey).

[9] *Ibid.*, p. 23.

[10] See National Commission on Teacher Education and Professional Standards, National Education Association of the United States, "The 1954 Teacher Supply and Demand Report," *Journal of Teacher Education*, March, 1954, pp. 9 and 21.

[11] Educational Testing Service, *op. cit.*, p. 16.

cies, in other words, have not been filled with qualified people."

The probable effect of the science-teacher shortage is an overall decline in the effectiveness of instruction. Also, many more schools are tempted to abandon the physical-science offering because suitable teachers cannot be found without considerable effort. In fact, many of our small high schools have long since inclined toward such a policy, in appreciation of the fact that unit costs of instruction in the physical sciences are likely to be higher than the unit costs of some other subjects.

The importance of superior high school science teachers has been pointed out by Brandwein [12] in a study of 82 science teachers who were singled out because they had stimulated numbers of students to participate in science fairs or in the Westinghouse National Science Talent Search. Brandwein was able to identify various common characteristics of these teachers, which might be accepted as a formula for success insofar as fostering student interest is concerned. From the standpoint of our present discussion the most significant fact about the 82 teachers was that they were acknowledged to be superior on a number of counts, and that they got results with their students.

If we attach significance to Brandwein's findings, one need becomes clear: the recruitment and training of a superior group of secondary-school science teachers. It goes almost without saying that such a group of science teachers will not be content with courses that have remained largely static for years, but will accept and participate in a program of modernization which has as its goal instruction that is related to contemporary experience. It will not be an easy task to recruit and train such teachers. The young college graduate recognizes that financial rewards for teachers are likely to be small, and that many teachers spend their days in the shadow of community criticism and a species of social ostracism. Nevertheless, the job must be done.

To summarize the teacher situation, it seems safe to conclude that the supply of scientific personnel in the United States tends to dry up at its secondary source because of a shortage of competent teachers, and concomitantly, because of the growing lack of an adequate and dynamic secondary school program of science and mathematics. *The average student arrives on the doorstep of the college without any recent background in mathematics or physical science.* If he ever had science interests they probably have been blunted by time and lack of cultivation. He often finds that he can obtain a B.A. degree with little or no attention to the sciences, and recognizing or suspecting the science deficiency in his own background of training, he is strongly disposed to cultivate other phases of knowledge.

It is only during the past two or three years that we have really been alerted to the apparent fact that student election of courses in the secondary school bears such a critical relationship to the decisions they make when they enter college. This new awareness has forced us to realize that college scholarships in the physical sciences are not enough to meet the challenge; in fact, the existence of a scholarship has little meaning if suitable applicants for the scholarship do not appear. In a word, there is reason to believe that the real "bottleneck" is at the secondary-school level, and that it is partly a problem of program and partly a problem of teacher supply.

Various attempts are being made to improve the existing situation, to bolster the secondary-school program of science and mathematics, to induce more young men and women to enter upon careers of high-school science teaching, and to encourage more high-school pupils to consider careers in scientific work. These efforts have

[12] Paul F. Brandwein, *The Gifted Student as Future Scientist*, New York, Harcourt Brace and Company, 1955, pp. 63–70.

taken various forms, including the college scholarship programs previously referred to. The last decade, for example, has been marked by a growing emphasis upon science fairs in the schools, and more recently by the establishment of various summer fellowships, work opportunities and special awards for high-school teachers of science. We also have the proposal of the Cooperative Committee on the Teaching of Science and Mathematics of the American Association for the Advancement of Science, which is designed to provide encouragement and support for prospective high-school science and mathematics teachers. The Board of Education of the City of New York has recently appointed an Advisory Committee on Scientific Manpower, under the Chairmanship of Dr. John R. Dunning, in a move to study the existing situation in the schools and to make recommendations for improved practices.

All of the efforts to meet the growing need of the present and future are commendable, and all of them should be continued and perhaps extended. It may be suggested, however, that *the key individual in the whole complex is the college instructor engaged in teacher training,* who elicits the interest of the prospective high-school teacher and prepares him to assume his duties, and who is often largely responsible when new or revised secondary-school science courses come into being. Yet up to the present time this college instructor has been largely the "forgotten man" in efforts to resolve the secondary-school science problem. Teachers College, Columbia University, has moved to remedy this deficit, the first step being to secure financial support from industries which recognize that their future personnel problems cannot be adequately met unless a suitable program of instruction has been maintained in the schools. Such support has been subscribed to date by the Aluminum Company of America Foundation, The American Gas and Electric Company, The American Metals Company, The Armco Foundation, The Auto-Lite Foundation, The Climax Molybdenum Company, The Continental Can Comapny, The Crown Zellerbach Foundation, The Ethyl Corporation, The Robert Gair Company, The General Dynamics Corporation, The Gillette Company, Handy and Harman, The International Business Machines Corporation, The International Nickel Company, The Kennecott Copper Corporation, The Link Foundation, The Pittsburgh Plate Glass Foundation, The Procter and Gamble Fund, The Rohm and Haas Company, The Sperry Corporation Foundation, The Standard Oil Company of California, The Standard Oil Company of New Jersey, The W. M. Welch Manufacturing Company, The West Virginia Pulp and Paper Foundation, and the Westinghouse Educational Foundation.

In keeping with our proposals to the aforementioned organizations, we have used the funds to establish a Science Manpower Project at Teachers College, Columbia University, which began operations on October 1, 1956. To this project we have brought representatives of science departments in institutions which train substantial numbers of teachers, as recipients of the fellowships established under the grants. These Fellows will participate in the project activities during the academic year, and will then return to their own institutions with the benefit of materials and methods developed by the Science Manpower Project. It is believed that they will inevitably serve as an effective force in the recruitment and training of the high school teachers that are so urgently needed today. Moreover, it is to be expected that the teachers trained by the former Fellows will carry the program down into the schools. Twelve Fellows representing ten teacher-training institutions are in residence during the current academic year, and it is anticipated that a similar group will carry on the work during the academic year 1957–58.

Activities of the project insofar as they are centered at Teachers College probably will involve the following emphases, although not necessarily all of them during the present academic year:

1. A thorough updating of the Fellows in modern theories of physics and chemistry.

2. Development of an improved program for the recruitment and training of high-school physical science teachers.

3. Establishment of cooperating agencies in the form of other colleges and individuals who will promote the work of the project on the national front.

4. Revision of existing secondary-school courses in chemistry and physics, and the development of suitable courses for the small high school.

5. Development of various teaching aids to support the high-school program of instruction.

6. Development of guidance materials for use in high school science departments and in the science departments of teacher-training institutions.

In summary, it is clear that a single institution cannot solve the scientific manpower problem, but can only serve as a moving force to initiate the effort. What is needed is a broad effect which will extend to many other teacher-training institutions, and from these institutions to the secondary schools of the nation, and thus ultimately to the secondary-school pupils. To date we have been greatly encouraged by the responses of various science educators who have volunteered to act as Corresponding Associates of the project, receive materials produced by the project, and give us the benefit of their best judgment and experience. We have every hope that this group of Corresponding Associates will continue to grow. Such a group can be of great assistance in achieving a broad impact upon the schools of the nation. Meanwhile, other organizations and groups of individuals have made initial attacks upon different phases of the problem.

It must be remembered that the scientific Manpower Project is only in its formative stage. Our first concern has been to establish the group of Fellows for the present year, and concomitantly, to develop working relationships with various other teacher-training institutions. It is a pleasure to be able to report that our overtures have been well received, and that good progress has been made. We are also concerned at the moment with the many administrative details which must be attended to before the project can be fully activated. We have every confidence that succeeding reports will reflect an accelerating rate of progress and a cumulative effect upon practices in the schools.

THE CRITICAL SHORTAGE OF SCIENCE TEACHERS

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THE concern of this paper is with the critical shortage of science teachers, especially in the "deep south." The present situation has been studied and presented for a number of years through the Maul studies prepared by the NEA Research Division at the request of the *National Commission on Teacher Education and Professional Standards* published annually in the *Journal of Teacher Education*. Analysis of such listings as the membership of the *National Association for Research in Science Teaching* reveals a startling dearth of members in the southern regions. These facts may or may not have implication for the alarming deficits in science education programs in this area for prospective teachers. That this problem, however, has more than regional significance is attested to by the persistence of articles

published in *Science Education* pertaining to aspects of the problem, the conferences on the training of science teachers sponsored by the *National Science Research Council,* the publication *Critical Years Ahead in Science Teaching,* and the special committee formulated by the *American Association for the Advancement of Science* to deal with the problems of supply and demand of science teachers.[1]

A recent study [2] indicated that 100 per cent of the elementary teachers surveyed had not had any course specifically designed for elementary school teachers of science; 75 per cent of these teachers had had only one course in science, General Biology; 46 per cent had had only one course in science, General Zoology; 28 per cent had had Nature Study; and 17 per cent had had a course in General Physical Science. When one considers the breath and scope of childrens interests in science, these teachers could not, by any stretch of the imagination, have been said to be adequately prepared to teach science education in the elementary schools. Further, the pupils prepared by these teachers would, in the same proportion, be deficient at the secondary school level.

At the secondary school level, general science and biology are the only science experiences a large majority of the students have. Chemistry, Physics, and/or Physical Science is taken by a relatively few students; in the areas of Chemistry and Physics enrolments have not expanded, appreciably, since 1930. In many regions, registration in these courses has consistently decreased during the past twenty-five years. The conclusion seems inevitable that present science courses do not appear to be attractive to the majority of the high school population.

When we look at the Office of Education figures on degrees conferred by institutions of higher education in 1950–51, the distribution of bachelor's degrees was:

Bacteriology	730
Bio-Chemistry	198
Biology	8,797
Botany	410
Chemistry	8,258
Geology	2,717
Meteorology	104
Physics	2,778
All other majors	361,360

Thus, at the onset of the "age of the atom" science, whose inventions and discoveries, and their application to technology, increasingly becomes an unpopular area of interest for prospective and in-service teachers. Much of this failure may lie in the distorted and misguided emphasis placed on the training of teachers, and in the recruitment of scientists by school, college, and university teachers of science.

Johnson and others [3] have studied the problem of why so many college students hesitate or fail to major in science. In an effort to explore the situation in Georgia,

[1] See, *The Journal of Teacher Education,* the 1950–1955 Teacher Supply and Demand reports.

F. L. Fitzpatrick, "Scientific Manpower: The Problem and Its Solution," *Science Education,* Vol. 39, No. 2, March, 1955.

Report of the Southeastern Conference on Biology Teaching, *The American Biology Teacher,* Vol. 17, No. 1, January, 1955.

Critical Years Ahead in Science Teaching, Report of Conference on Nation-wide Problems of Science Teaching in the Secondary Schools, held at Harvard University, Cambridge, Mass., July 15–August 12, 1953.

[2] Katheryn Vernratha Middleton Brown, *A Study of Undergraduate Professional Education of Elementary School Teachers with Special Emphasis for Teaching Science,* unpublished master's thesis, Atlanta University, Atlanta, Georgia.

[3] *Science Education in American Schools, National Society for the Study of Education,* Forty-Sixth Yearbook, Part 1.

D. Wolfe, "Intellectual Resources," *Scientific American,* September, 1951.

Phillip G. Johnson, "Occurrence of Science Courses in American High Schools," *Bulletin of the National Association of Secondary School Principals,* January, 1953.

———, *The Teaching of Science in Public High Schools,* Federal Security Agency, Bulletin No. 9, 1950.

Frank Bowles, "The Future Supply of Scientists," *The Educational Record,* April, 1954.

Margaret E. Patterson, "The Key to Our Scientific Manpower Shortage," *Science Teachers and the Science They Teach, Books in Their Courses,* Vol. 12, No. 2, April, 1954.

an effort was made to discover the extent to which the generalization that "college science majors constitute a declining proportion of the college group as a whole," applies in this state. A survey was therefore made of the graduates listed by the State Department of Education as "qualified" to teach. The graduates of nine institutions preparing teachers were analyzed for a period of six years. *All* individuals listed in the yearly list with either major or minor sequences in a field or fields of science were tabulated. This paper presents the results of that study.

TABLE I

MAJOR-MINOR* COMBINATIONS IN NINE GEORGIA COLLEGES—1950–1955

(Combinations Listed Are Those Present in the Cousin's Lists)

	Totals	AL	AU	CL	FV	M	MB	P	S	SP
BIOLOGY—Chemistry	35	0	3	11	0	11	1	0	9	0
BIOLOGY—Social Science	1	0	0	0	0	0	0	1	0	0
BIOLOGY—Mathematics	8	0	0	0	0	0	0	2	3	3
BIOLOGY—Psychology	4	0	1	0	0	0	0	0	0	3
BIOLOGY—English	2	0	0	0	0	0	0	0	0	2
BIOLOGY—Art	1	0	0	0	0	0	0	0	0	1
BIOLOGY—Spanish	2	0	0	0	0	0	0	0	0	2
BIOLOGY—History	12	0	0	0	0	0	0	0	0	12
BIOLOGY	5	0	1	0	2	0	1	0	0	1
ZOOLOGY—Mathematics	1	0	0	0	1	0	0	0	0	0
ZOOLOGY—Education	6	0	0	0	6	0	0	0	0	0
ZOOLOGY—Chemistry	3	0	0	0	1	2	0	0	0	0
PSYCHOLOGY—Biology	2	0	0	0	0	0	0	0	0	2
SOCIAL SCIENCE—Biology	1	0	1	0	0	0	0	0	0	0
CHEMISTRY—Biology	3	0	0	2	0	0	0	0	1	0
CHEMISTRY—Mathematics	6	0	1	0	1	3	0	0	1	0
CHEMISTRY—Education	3	0	0	0	1	0	0	1	1	0
CHEMISTRY—Social Science	1	0	0	0	0	0	0	1	0	0
CHEMISTRY	1	0	0	0	1	0	0	0	0	0
SCIENCE EDUCATION	1	0	0	0	1	0	0	0	0	0
HOME ECONOMICS—Chemistry	2	0	0	1	0	0	1	0	0	0
HOME ECONOMICS—Natural Sci.	13	0	0	1	0	0	0	9	0	3
HOME ECONOMICS—General Sci.	10	10	0	0	0	0	0	0	0	0
HOME ECONOMICS—Science	32	16	0	0	0	0	2	5	2	7
MATHEMATICS—Physics	5	0	0	3	0	2	0	0	0	0
MATHEMATICS—Biology	2	0	0	0	0	1	0	0	0	1
MATHEMATICS—General Science	5	0	0	0	0	0	0	0	0	5
SCIENCE	5	0	0	0	3	0	2	0	0	0
NATURAL SCIENCE—El. Ed.	4	0	0	0	0	0	0	4	0	0
NATURAL SCIENCE—Mathematics	8	0	0	0	0	0	0	8	0	0
NATURAL SCIENCE—Physics	1	0	0	0	0	0	0	1	0	0
NATURAL SCIENCE—Social Science	9	0	0	0	0	0	0	9	0	0
NATURAL SCIENCE—Chemistry	3	0	0	0	0	0	0	3	0	0
NATURAL SCIENCE—Education	3	0	0	0	0	0	0	3	0	0
NATURAL SCIENCE—Biology	1	0	0	0	0	0	0	1	0	0
NATURAL SCIENCE	12	0	0	0	1	0	0	10	1	0
GENERAL SCIENCE—English	2	0	0	0	0	0	0	0	2	0
GENERAL SCIENCE—Mathematics	4	0	0	0	0	0	0	4	0	0
GENERAL SCIENCE	10	0	0	0	0	0	0	1	9	0
AGRICULTURAL ED.—Natural Science	1	0	0	0	0	0	0	0	1	0
ENGLISH—Science	0	0	0	0	0	0	0	0	0	0
ELEMENTARY EDUC.—Science	5	2	0	0	3	0	0	0	0	0
AGRICULTURAL ED.—Science	1	0	0	0	1	0	0	0	0	0
VOCATIONAL AG.—Science	1	0	0	0	1	0	0	0	0	0
ZOOLOGY	5	0	0	0	5	0	0	0	0	0
	242	28	7	17	29	19	7	63	35	37

* Capital letters indicate major; lower case letters indicates minors.

TABLE II

GRADUATES BY INSTITUTIONS, YEARS, MAJOR-MINOR COMBINATIONS

	1950	1951	1952	1953	1954	1955	Totals
ALBANY							
HOME ECONOMICS—General Science	0	10	0	0	0	0	10
HOME ECONOMICS—Science	16	0	0	0	0	0	16
ELEMENTARY EDUCATION—Science	0	0	2	0	0	0	2
ATLANTA UNIVERSITY							
BIOLOGY—Chemistry	1	2	0	0	0	0	3
BIOLOGY—Psychology	0	1	0	0	0	0	1
BIOLOGY	0	0	0	0	0	1	1
SOCIAL SCIENCE—Biology	0	0	1	0	0	0	1
CHEMISTRY—Mathematics	0	0	1	0	0	0	1
CLARK							
BIOLOGY—Chemistry	7	1	0	2	1	0	11
CHEMISTRY—Biology	1	0	0	0	1	0	2
HOME ECONOMICS—Chemistry	0	1	0	0	0	0	1
MATHEMATICS—Physics	1	0	1	0	1	0	3
FORT VALLEY							
BIOLOGY	0	0	1	0	0	1	2
ZOOLOGY—Education	0	0	0	2	4	0	6
ZOOLOGY—Chemistry	0	0	0	1	0	0	1
ZOOLOGY	0	2	0	0	0	3	5
ZOOLOGY—Mathematics	0	1	0	0	0	0	1
CHEMISTRY—Mathematics	0	1	0	0	0	0	1
CHEMISTRY—Education	0	0	0	0	1	0	1
CHEMISTRY	0	0	1	0	0	0	1
SCIENCE EDUCATION	0	0	1	0	0	0	1
HOME ECONOMICS—Natural Science	0	0	0	0	1	0	1
SCIENCE	0	0	2	0	0	1	3
NATURAL SCIENCE	0	0	0	0	0	1	1
ELEMENTARY EDUC.—Science	0	0	0	0	3	0	3
AGRICULTURAL EDUC.—Science	0	0	0	0	1	0	1
VOCATIONAL AG.—Science	0	0	0	0	1	0	1
MOREHOUSE							
BIOLOGY—Chemistry	0	0	0	11	0	0	11
CHEMISTRY—Mathematics	2	0	0	0	1	0	3
MATHEMATICS—Physics	1	0	1	0	0	0	2
ZOOLOGY—Chemistry	0	0	2	0	0	0	2
MATHEMATICS—Biology	0	0	1	0	0	0	1
MORRIS BROWN							
BIOLOGY—Chemistry	0	1	0	0	0	0	1
HOME ECONOMICS—Chemistry	0	1	0	0	0	0	1
HOME ECONOMICS—Science	0	2	0	0	0	0	2
SCIENCE	0	0	1	0	0	1	2
BIOLOGY	0	0	1	0	0	0	1
PAINE							
BIOLOGY—Social Science	1	0	0	0	0	0	1
BIOLOGY—Mathematics	1	0	0	1	0	0	2
NATURAL SCIENCE—Elementary Education	4	0	0	0	0	0	4
NATURAL SCIENCE—Social Science	4	0	4	1	0	0	9
HOME ECONOMICS—Natural Science	4	0	5	0	0	0	9
CHEMISTRY—Education	1	0	0	0	0	0	1
CHEMISTRY—Social Science	0	0	0	1	0	0	1
HOME ECONOMICS—Science	0	5	0	0	0	0	5
SCIENCE (NAT.)—Mathematics	1	0	5	2	0	0	8
NATURAL SCIENCE—Physics	0	1	0	0	0	0	1
NATURAL SCIENCE—Chemistry	0	0	0	0	3	0	3
NATURAL SCIENCE—Education	0	0	2	0	1	0	3
NATURAL SCIENCE—Biology	0	0	0	0	1	0	1
NATURAL SCIENCE	0	0	1	0	0	9	10

TABLE II—*Continued*

	1950	1951	1952	1953	1954	1955	Totals
GENERAL SCIENCE—Mathematics	0	0	1	3	0	0	4
GENERAL SCIENCE	0	0	1	0	0	0	1
SAVANNAH							
BIOLOGY—Chemistry	4	4	1	0	0	0	9
BIOLOGY—Mathematics	3	0	0	0	0	0	3
CHEMISTRY—Biology	0	1	0	0	0	0	1
CHEMISTRY—Mathematics	1	0	0	0	0	0	1
CHEMISTRY—Education	1	0	0	0	0	0	1
HOME ECONOMICS—Science	0	2	0	0	0	0	2
MATHEMATICS—General Science	0	0	0	1	4	0	5
NATURAL SCIENCE	1	0	0	0	0	0	1
GENERAL SCIENCE—English	0	0	0	1	1	0	2
GENERAL SCIENCE	2	0	0	0	0	7	9
AGRICULTURAL EDUC.—Natural Science	0	1	0	0	0	0	1
SPELMAN							
BIOLOGY—Mathematics	3	0	0	0	0	0	3
BIOLOGY—Psychology	1	2	0	0	0	0	3
BIOLOGY—English	1	0	0	1	0	0	2
BIOLOGY—Art	0	1	0	0	0	0	1
BIOLOGY—Spanish	0	1	0	0	1	0	2
BIOLOGY—History	0	0	6	2	4	0	12
BIOLOGY	0	0	0	0	0	1	1
PSYCHOLOGY—Biology	0	0	1	0	1	0	2
HOME ECONOMICS—Natural Science	0	0	1	0	2	0	3
HOME ECONOMICS—Science	0	0	0	7	0	0	7
MATHEMATICS—Biology	0	1	0	0	0	0	1

SUMMARY

The nine institutions involved in this study, reported 44 different opportunities or combinations for a student to secure a major and/or a minor in an area of science, during the period 1950–55. The following facts appear pertinent:

1. A total of 242 individuals were listed as qualifying through a major or a minor in an area of science, for the six year period.
2. Of this 242, 84 had majors in Biology or Zoology; 14 in Chemistry. Hence, a total of 98 "majors" graduated or were listed as "qualified" during this period. There were *no Physics* majors listed for this period. (Major, as used here, refers to a listing of Biology, Chemistry, Physics, and "traditional liberal arts categories.")
3. One hundred forty-four of the 242 individuals "qualified to teach" were either minoring in science, or majoring in "Natural Science," "Science," "General Science," or in a related field such as Agricultural Education, Mathematics, Home Economics, or Vocational Agriculture.
4. Only one individual was reported for this period as having a major in "Science Education."
5. Of the 242 individuals listed as "qualified," the nine institutions were responsible for their training as follows:

   28 graduated from Albany State College
   7 graduated from, or attended, Atlanta University
   17 graduated from Clark College
   29 graduated from Fort Valley State College
   19 graduated from Morehouse College
   7 graduated from Morris Brown College
   63 graduated from Paine College
   35 graduated from Savannah State College
   37 graduated from Spelman College

6. The number of individuals listed as "qualified" through possession of either a major or a minor in science decreased through the six year period as follows:

   62 graduated or qualified in 1950
   42 graduated or qualified in 1951
   44 graduated or qualified in 1952
   36 graduated or qualified in 1953
   33 graduated or qualified in 1954
   25 graduated or qualified in 1955

7. The number of individuals listed as "qualified" through possession of a "traditional" major in Biology, Zoology, or Chemistry (no Physics majors were reported for the period studied) was as follows:

   27 in 1950
   18 in 1951
   12 in 1952
   21 in 1953
   14 in 1954
   6 in 1955

8. There has been a consistent and general decline in both the listings of individuals "qualified" to teach on the basis of a major, a

minor, or other indications of related fields to science. For the six year period studied, the decline in majors was from 27 in 1950 to 6 in 1955; the decline in minors is equally alarming. The decline in all areas (listings of major and minor combined) was from 62 in 1950 to 25 in 1955.

CONCLUSIONS

It is believed that at the college and university level, too many of the individuals who are responsible for programs in which prospective and in-service teachers participate, stress the demands for technically trained scientific personnel whose destiny is industry and government. This appears to be the result of industry and government offering more wages than teachers may secure. Hence, college and university personnel tend to direct promising youth away from the teaching profession for other jobs offering higher remuneration. Thus, teacher training recruitment into the teaching profession becomes increasingly unattractive to prospective science teachers.

However, data on the current supply for new science teachers in Georgia indicates that there has been a consistent decline in individuals listed as "certified" to teach science. The implications for future scientists and "teaching scientists" are clear. Faced with a shortage of science teachers, schools often operate on the premise that courses will continue to be offered, and the assignment in science courses goes to an employed teacher whose special competency may lie in another field than science. It is true that at present we do not have enough scientific personnel for either industry, government, or university research. However, the readiness with which those individuals who are competent in science are caught up in non-teaching fields has made it difficult to retain competent individuals to teach science to the children and youth. Consequently, our raw material, the children and youth, from which future scientists will emerge, has been seriously depleted. There is no element within the present situation from which science educators, and the American people in general, can draw satisfaction, or take comfort.

RUSSIA CAN VIEW WITH SATISFACTION OUR DILEMMA IN TECHNICAL EDUCATION *

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LAST year, Russia graduated 50,000 engineers while we produced fewer than 25,000. This year the divergence is expected to be even greater. Moreover, our engineering graduates who usually leave college after receiving a bachelor's degree are deficient in the study of mathematics, physics, and chemistry as compared with Russia's engineering graduates. There is evidence that we are doing no better, relatively speaking, in the fields of science. For example, we need 7,700 new science teachers each year for our high schools, but we are producing only one-third of this number. The figures are not as readily available in regard to Soviet production of scientists but the Russian system of incentives appears certain to produce as many scientists as the Soviets desire. These incentives are a free education for brilliant youngsters in the fields of science and engineering plus a high social and economic position for successful graduates in these fields and particularly so for those who become teachers. Why should a country that can produce eight million new automobiles in a single year find itself unable to compete with the Soviets in technical and scientific education? This question has the greatest politi-

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cal implication since by means of its surplus engineers, Russia will soon be able to provide aid in industrializing the "have-not" countries of Asia and Africa. Following closely behind the importance of Russian engineers and machines will inevitably come economic and political ties into the Soviet satellite system.

Today, scientific education in the United States is suffering from the low birth rate of the 1930's, but even as youngsters born after the war enter our colleges, we will not produce enough engineers and scientists to meet the needs of our own country.

These studies require intense concentration and a high level of intelligence while the rewards paid by industry and government are not sufficient to attract more than ten or twelve per cent of college students into these fields of study. Another bottleneck is in the cost of a college education and particularly of post-graduate education for the master's or doctor's degree. If we are to compete effectively with Russia in this field of her own choosing, we will have to give greater consideration to the incentives by which that country has induced a very high percentage of her college students to study science and engineering. As a first step, we must offer greater financial inducements to high school and college teachers who are willing to undergo the rigorous preparation for effective teaching in these fields.

The Soviets have adopted the American incentive system and applied it with a vengeance to their educational programs where it has had no application in America. Russia needs more engineers and scientists. Ergo! Science students receive an incentive pay of 290 to 450 rubles per month according to Dr. Weldon H. Brandt of Westinghouse Research Laboratories who has just returned from Russia. This incentive stipend goes up for outstanding scholarship and reaches the same pay for a graduate student (780 rubles per month) as for a beginning engineer in industry. In this country perhaps one undergraduate in ten is given a scholarship that will cover tuition and books while a graduate student who works half-time for the university can earn only one-third of the income he would receive in industry.

In Soviet circles, the incentive for teachers is even greater to remain in the educational system and to become the goose that lays the golden eggs of science. The youngest college instructors receive 1,350 rubles per month which is increased to 1,750 for those with the equivalent of master's degrees. This rate is fully equivalent to the salary of a mature engineer in Russian industry. By comparison, our engineering and science instructors are paid about $5,000 per year, which is one-half of an average industrial scientist's salary. The discrepancy is even greater for full professors who are paid twice as much in Russia as top-flight practicing engineers or typical industrial managers, while in America a full professor must live on one-half of a comparable industrial salary. Relative to other competing salaries, Russia therefore offers an enormous incentive, both economic and in social prestige, to the finest scientists and research engineers to remain with the universities. We are permitting our best minds to drift into industry because of a lack of such incentive in our universities.

Since the cost of producing incentives to faculty and graduate students as well as the upper level of undergraduates is certain to be very high, it behooves every educational institution to review the importance of its regular expenditures.

Traditionally universities have been centers of learning. Formal teaching developed naturally as young minds sought the companionship of mature scholars. Wherever such scholars gathered for discussions, whether in a corner of the market place, in a temple or a drinking hall, that place became an educational institution and furnished the essential beginning of a university. The assemblage of scholars was and remains today the essential feature of

any university. It can be assumed without chance of error that students will always be present where scholars gather. All other features of a university including educational buildings and dormitories, an administrative system, research laboratories and curricula should serve one of two purposes. Each new or repeated expenditure should either make the university more productive of research or it should make the transfer of knowledge more certain. If it is for any other purpose, it can be sacrificed in time of strain when questions must be raised as to the ability of the university to serve its two primary functions adequately.

It has been said that the American university has taken on the appearance and accepted something of the underlying concept of the American supermart. Whatever a student wants apparently must be furnished on the campus. There are hundreds of courses not very clearly allied to education; there are elaborate athletic programs, overdeveloped counseling systems and an undue proportion of attention given to housing, feeding and caring for the student's non-educational needs. Insofar as graduate education is concerned, those who are worried about the teaching of communism in our classrooms should turn their glance in another direction. The real danger is that we will have indoctrinated our undergraduates in the acceptance of paternalism in the university to the extent that they will not recognize the dangers inherent in socialism when practiced more widely.

In addition to the undergraduate emphasis upon non-essentials, we have enormous extension systems that demand the attention of our universities. In some fortunate institutions, extension is almost a separate function. Its integration into the fabric of the university produces another service objective that competes for attention and for funds. There is no question about its justified position in a university, but there is strong question as to whether our universities are conducting their primary functions well enough at the moment to justify the time and money for activities other than research scholarship and resident teaching.

In all studies of universities, the most important consideration is the quality of the faculty. In the scientific and engineering field, one sees no evidence of optimism in regard to recruitment. Hence I wish to analyze the problem of faculty recruitment to draw from it the lessons of the past and to search for whatever light we may find. Traditionally, engineering faculties were teaching faculties rather than research faculties. This tradition is still very strong although it is no longer paramount. The war research program and the post-war contract research program have introduced research as a major activity into a majority of engineering colleges.

In order for universities to maintain their positions as centers of research, they must be able to employ a few distinguished research scientists and engineers and a large number of the best young minds from among their graduates. The universities were stripped of manpower by the war, but in the early post-war years they were able to reconstruct their faculties in a reasonably effective manner. There is considerable encouragement in this observation because it was not through high salaries that this was accomplished. Nevertheless, salaries were radically improved over prewar years, inflation had only started and industry was having reconversion troubles so that its returning engineers from the services met its temporary needs.

In four years, the flow of engineers and scientists from education into industry reached its all-time peak meeting all industrial needs. Our engineering and science departments were able to strengthen their faculties by retaining or hiring some of the strongest graduates with advanced degrees. Historically, we may well point to the years 1951–53 as the peak of excellence of scientific and engineering faculties

on a country-wide basis. Since 1953 the salary discrepancy between industry and education has been increasing steadily. Engineering graduates this spring will for the first time receive at least $5,000 per year while those who show some special aptitude or interest in research seem slated to receive up to $6,000. These salaries cover the range of assistant professor in many institutions for which we have traditionally expected about five year of experience and for which we should be requiring a Ph.D. degree. Such an unbalance in salaries would be ludicrous if it were not so deadly serious not only in terms of the needs of our own country but because of the brilliant plan of our industrial rival, Russia, to out-point us in the field of education where our traditions limit our ability to compete.

In this consideration of the problems of the university we must not forget that the difficulties centering around science education start in the public schools. The contest for subject-matter attention has been lost by the proponents of science to those who emphasize social science and adjustment of the individual to his environment.

The National Science Foundation budget for 1956–57, which proposes $9,500,000 to aid in producing and holding science teachers for our high schools, is the first recognition in Washington of the fact that we are facing a crisis in the production of scientists and engineers. This is only the first drop poured into a very dry bucket that must be made to overflow if we are to compete with Russia in this unwelcome new cold war to be waged through education and technology. Some of the necessary funds will come to private institutions from individuals and partciularly from industry. However, industry is not likely to aid state universities in doubling educational salaries (Beardsley Ruml finds that many educational salaries should be tripled to reinstate the buying power of top professional positions) in order for our colleges to compete with industry for scientific and engineering brainpower. And with the great numbers of new students needing a general education at the freshman and sophomore levels, our states will be pressed to build the new community colleges to care for them. It seems that the Federal Government cannot fail its responsibility for underwriting at least in our public universities and Land-Grant Colleges the extensive costs of scientific and engineering education in terms of incentive scholarships, salary supplements and further support for the most fundamental research. Strong incentives are needed to attract brainpower to our faculties and also the large numbers of students of the highest intellectual capacity to compete in the scientific educational race now being dominated by Russia.

Attention must be called to the limited time left to us to reach some highly critical decisions. President Eisenhower recently announced his intention to appoint a study committee for the entire field of higher education. But we are informed that this committee will not make recommendations but will only suggest problems for further study. The problem of our educational race with Russia in technology is already well enough defined for initial steps to be taken. We must increase the amount and improve the quality of scientific and technological education from the high school to the Ph.D. degree. It will require extensive educational funds from Federal, State and Local Governments, industry, foundations and private donors to counteract the Soviet bid for world leadership through technology.

Research in a university is synonymous in the science and technical fields with scholarship, and scholarship is the main source of institutional prestige. As a matter of fact, there is no other source of institutional prestige for a university as contrasted to an undergraduate college. The university that does not offer scholarly atmosphere through research is misnamed as a university since it is merely a collection of undergraduate colleges. Such an institution fails in depth and may be

compared to the two-dimensional frame of established knowledge where the third dimension of insight into the future through research and scholarship is essentially missing.

The attainment of a scholarly atmosphere depends in a small way upon the attitude of the university administration but in large measure upon success in attracting and developing and holding scholars and researchers in the university. For the fields of physical science and engineering, the flow has been outward for several years until it seems certain that a serious crisis is in the making. The flow of scholars must be reversed for several years until the universities have been staffed for the job of handling much larger numbers of students. The safety of this country demands that the university be staffed promptly to handle twice as many students as presently are being graduated in science and engineering at undergraduate and graduate levels.

There is that irreducible number of scholars in any field who find any atmosphere except the university so unsatisfactory that transfer to a government or industry position is unthinkable. These deserve every honor we can accord them. But the evidence is clear that they do not exist in sufficient numbers in the professional fields. If Russia finds it wise to compensate a research scholar twice as well in the university as in industry, we can not expect to reverse the order of compensation without strained results. Every administrator can testify to the fact that the strain in building a scholarly faculty is greater today than ever before.

It appears that the wheels are now moving slowly toward a national reconsideration of the problem of financing science instruction. If a solution is found, our universities can move forward as strong leaders in research. If the present lack of incentive for research scholars and graduate students to assemble within our universities continues, or if the relative incentive for such individuals to move into industry should increase, the gradual disappearance of research from the scene of American engineering and science education could result. Since funds from all sources will be severely strained to meet this new demand, it is incumbent upon the universities to use every economy and to reconsider all expenses not directly related to the central job of teaching and research. Because the ultimate answer will be synthesized from the working of many minds in government, industry, education, the great foundations and the American public, it is our responsibility to explain the dangers and opportunities as widely as possible. The future not only of American technical education but of the American way of life may be dependent upon the decisions reached.

CRITICISMS OF EDUCATION

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An imposing array of words is piling up in criticism of the educational process and in defense against this criticism. Unquestionably most of the critics of education feel that they are not merely belittling but are endeavoring to provide bases for correction which would make criticism unnecessary. Quite as surely most of the defenders of education feel unfairly put upon, rather than that their methods and brethren are too perfect for criticism.

Except for the fruits of discussion and the effects of challenge, little can come from this bickering. Much of it is rather immature. Critics who often know little of schoolrooms blame teachers for human fail-

ings which, of course, they have; and many teachers, thus upset by their brethren, students, and citizens, feel a little desperate. The principal burden must be carried by the victims of the criticism, the teachers. They will always be vulnerable, especially to emotional charges from students and parents.

Teachers should be vulnerable, and not merely because, as goes without saying, they are imperfect. They should be vulnerable for a truly great reason. Teachers carry a serious responsibility for basic knowledge, the process of learning, and the search for truth, but they have no obligation, except in terms of reasonable social integration, to please students and parents. In that right moves are often not too well received, criticism can even be a normal expectancy and a compliment.

Recently I heard a brief discussion over whether or not students should be made unusually comfortable in lectures, on the theory that too much comfort might predispose to sleep and inattention. The debate concluded in favor of reasonable comfort, with the opponents losing ground before an uncomfortable audience squirming in poorly constructed seats. We live in an atmosphere of pleasing customers, gaining votes, winning constitutents, and arbitrated compromise. We consider courtesy to be an easy way to improve the day and graciousness to be a virtue. The fact remains that the teacher who caters to students to curry favor, at the sacrifice of good teaching, is not serving courtesy as he imagines or meeting a demand as seems to be the case, but is following a shortsighted expediency at the expense of what may be right. "It hurts me more than it hurts you."

This point is not easily balanced. Teachers who are inately stubborn or opinionated may well look to their laurels, for this principal does not make them right. Unless they are right, they cannot boast that they pursue the right regardless of criticism, thereby protecting themselves under this principle. By the same token, teachers who are polite, considerate, or even politic are in danger of rationalizing that it is proper to concede to the wishes of the many, not realizing that good solid performance may well be at times against these wishes. This point of balance can be seen by thinking of the caricatured Spartan New Englander, fighting against an act solely because it is a pleasure and hence to his mind sinful, in contrast with the caricatured lazy man, who argues against the performance of his duty because it makes him unhappy. We need a balance of antithetical choices. This is close to the heart of many arguments about education, one group calling for stern *right* measures, with less softness, and the other arguing against any inhibition because inhibtion is deemed a sin in itself. We can arrive nowhere in a dispute on education unless we can do so with an intention of striking a balance between the two, preferably seizing the virtues of each and leaving behind the disadvantages.

This brings us to the essence of our problem, the criticism of education and the manner of receiving and responding to it. The answer is a simple concept in two phases, easy to understand and difficult to carry out only because it takes in all who teach, most of us with normal human reactions. The two phases are these: First, criticism must be accepted for inspection; second, there must be an adult and mature response to it.

Acceptance of criticism, if only in the same way that the Post Office accepts packages on faith, is essential. The fact that someone may mail liquor, obscene literature, or a bomb does not justify unlimited challenge and suspicion against everyone who goes to the mailing desk. Very few violate the rules knowingly, deliberately building on trust earned by those who deserve it. By the same token, the average critic, right or wrong, is at least sincere.

In plain English, though we may view with suspicion and sometimes alarm the persistent seeker of criticism, we who teach

must be receptive to any and all criticism that is directed our way. We cannot prejudge its merit. We cannot estimate its sincerity without cool inspection. We cannot weigh criticism which may violate the rules until we have inquired into it, even when we suspect that it violates the rules, probably unwittingly.

This calls for neither subservience nor superciliousness. To receive criticism for calm inspection, however evident its thinness or emotional content, does not alter the right to question or to reject it. To receive it is common courtesy and decency. It is in every sense proper, since our students are the children of those who built the schools and pay our salaries. It is even good tactics. But primarily it is just good sense, for surely every teacher should know that he is not infallible, and every criticism is (1) an attempt to improve things as the speaker sees them, and (2) an index of conflict which, granting that some of it is inevitable, is still better when kept at a minimum.

On a sheet on which records of medical students are sometimes kept is an entry: "Receptiveness to criticism." The teachers, in this case the critics, expect certain responses to criticism. This does not include rejection, defensiveness, belligerence, dejection, or subservience. It does include receptiveness, understanding, consideration, and judgment in the use of criticism. Should less apply to a teacher's reception of criticism than applies to students' reception of criticism by these same teachers? Some will say "yes" with vigor, saying that lay criticism of a professional group has no equivalence with professional criticism of an inexperienced group. Valid though this is, I challenge its propriety on these grounds: receptiveness of criticism is a principle in and of itself, regardless of the parties concerned. Truth may come from the mouths of babes, and wise men often criticize in error. Even tactically, an abysmal approach, he who is receptive to criticisms with judgment and without subservience pulls the emotional fire from an emotional critic by his willingness to take the criticism in hand and inspect it when rejection with equally vigorous emotion is expected.

The second phase of reaction to criticism of education which seems to be needed is the demonstration of a mature attitude and response to it.

Critics include imperious students whose criticisms are patently juvenile, but they often have fresh viewpoints and they do reflect directly the teaching itself. Critics include parents, often frightening in their confusion, yet surely they have a vote, they have knowledge of pupils and students that teachers should want and need, and in truth together with teachers they carry virtually all the overlapping educational responsibilities for youth. Critics are sometimes employers, likely to make ill-considered and childish charges based on their displeasure; Suzy can't spell. Yet our Commencements turn students loose to employers, and, juvenile or not, charges made, if right, must be met or, if they are wrong, must be answered. Teachers, educators, alumni and all groups who have interests at stake include critics, not all of them emotional or juvenile. There may be mature and honest differences of opinion.

Broadly considered, criticism which is disturbingly unacceptable is immature, it is unreasoned emotionalism, or, most fatal of all, it arises from the belief that all faults can be overcome by teaching. Since teachers like to feel that they accomplish things with their students and are likely to remedy deficiencies with new courses, they often foster this kind of criticism which then disturbs them.

In any event, a mature approach to criticism of education will not allow irritation toward juvenile charges, emotion toward emotional challenges, or impatience toward accusations of failure which presuppose that teachers are responsible for all knowledge and all characteristics that appear in their graduates. If this seems to be asking too much, we need only examine our

thesis of freedom of thought, so essential to any search for knowledge and truth, for by its rules any accuser, right or wrong, is entitled to his share of speaking time.

Part of the sensitivity to criticism arises only because many of us prefer to live in a more charitable atmosphere and feel irked at the constant search of the appraising eye, in much the same way that a harping critic looking for small defects, if sitting behind you, can ruin an otherwise pleasant performance at the theater. What we think of the uncharitable and harping critic of education is a matter of opinion; a good case can be made against them, especially those who, when challenged, cannot say what is right about education but demonstrate that they are mere faultfinders. The fact remains that this breed of man exists and that nothing is going to stop his criticism except muzzling, which is unthinkable, or a better approach to his inevitable criticism, which we here bespeak.

I have refused to read formal criticisms from students some of whom, handed a questionnaire by busy committeemen among their numbers, wrote out answers to these questionnaires and permitted the committeemen to arrange their thoughts as they chose. This may be wrong, for some of the criticism is sure to be valid, though, since I offer opportunities for criticism and have a standing offer to name two faults on which I work for every one others can name, I seriously question whether *new* ones are there, but a manipulated breeding of anonymous criticism has to be rejected, just as the harping critic at a movie should be ejected if he has neither the sense nor courtesy to stay away. This type of criticism, since it is chronic and says only in effect "there are faults and I am unwilling to rise above them," can only be met by ignoring it, by blocking it, or by strategy. This form of criticism is worth weighing only in terms of strategic receptiveness. In the instance cited, I have tried to work for (1) a solid receptiveness by teachers for serious criticism that rises above this level of chronic trivia, so that criticism worth while finds a place, and (2) a realization by students that their task is serious and their teachers are human, and, if they are going to devote their time to analysis of trivial foibles instead of demonstrating either indifference or charity while they tend to their duties, they better seek a more harmonious environment or, perhaps, philosophy. There are, of course, teachers who exhibit this same air of chronic faultfinding toward students, whom they should be teaching instead, with decent charity and understanding. The same things can be said of these teachers. It is a poor rule that works only in one direction. We may even add that, if teachers fail to tend to business because criticisms take too much time, the critics will really have a field day.

Once we attain a mature poise in attitude toward the criticisms of education, we can look calmly at juvenile and emotional ideas and can sort out those which are based on true ignorance. These particularly require a maturity of wisdom, for confusion of ignorance and intelligence is often behind both criticism and our reaction to it. That is, I might make charges to which a professor of philosophy would take marked exception because of experience in his own field of which I am ignorant; my error would be attributable to ignorance, yet to be valid his exception to my challenge would have to be based on sound conclusions from his greater knowledge and not on a mere difference of opinion. Or, I might be challenged by a highly intelligent man who had never gone beyond the fifth grade. Based on his scholastic status I would be in danger of calling him a fellow who did not know whereof he spoke, whereas his intelligence might put him way out in front.

With these considerable precautions, criticisms can be screened judiciously, faced calmly, and accepted or answered, as the case may be, with every due and proper regard for the critic. He is to be belittled

only if he is malicious, which is unlikely. He is entitled to an answer, to an explanation, to an enlargement of viewpoint, if necessary, since he has been courteous enough to show interest. Surely, if we who teach have any faith in education, we can afford to try education on our critics. If we become unduly disturbed, they become more than ever disturbed and are none the wiser. We cannot explain every move and should not have to, but within limits we must tell them what we are doing and why, and do it with the mature wisdom of teachers. The friendly and neighborly explanation is a better teaching procedure than an attempt to impress by an air of authority.

Among criticisms is the more difficult type of challenge, that which assumes that the student who errs in arithmetic is not so wrong as was his teacher, that the error in spelling is the fault of a past teacher, that the medical error would not have been made if the teacher had been on his toes, that judgment is unbalanced or bigoted because of a teacher, his chief, the method of his school, or perhaps the methods of all schools.

These criticisms arise because someone's act or decision goes awry, the error has to be blamed on someone, and teachers make easy and natural, sometimes even gullible victims. There are many of them, too vaguely defined to strike back. In spite of the endless flow of their language, they are often oddly inarticulate in everyday language. Quite deeply entrenched in many minds, too, is the thought that pupils and students are what teachers make them. Teachers themselves, anxious to feel that they have accomplished something, often help to build this idea, but it is fatal.

Whatever modern educationists and psychologists may say, and whatever wise old men and ancient philosophers may say, all pupils and students start with some different deeply inborn and inherent talents and characteristics which are molded somewhat but not basically altered by familial and neighborhood environment. On these separate talents and characteristics, so modified, the teacher builds what knowledge, intellectual muscle-building, and guided environmental teaching he or she can. This point can constitute a debate of the first magnitude, if we divide up these factors and become specific. Here, however, it is inviolate, for in its collective whole the point is unequivocal; only when dividing lines are drawn is there debate. The unequivocal whole demonstrates beyond doubt that the teacher's role is finite and not infinite. Whatever the boundaries may be, they cannot be passed. The teacher cannot, should not, and does not supplant the gene, the parent, and neighborhood experiences; he or she adds to them. The teacher who wants to feel that he molds the student to his pattern is fooling no one but himself, and his failure is ordained. He would be smart to admit it, with the rest of us. Each student has a certain type of intelligence, a rapidity of mind, a sharpness of eye, a quickness of hand, a memory, and a mental agility in this or that direction. He also has a will, weak or strong, balanced or warped, which is not passive but must be met squarely.

This point would carry us directly into the heart of modern challenges to education, if debate over what is wrong and right with education were the present issue, for people both in and out of schools disagree as to what is unchangeable and what can be changed by right training. This discussion is concerned only with criticism as such; those who go to extremes in either direction of criticism are wrong *ipso facto*. The educational problem is to lay before the teachers' assembly, the school board, and the jury of the populace the intention of teachers and the natural limitations, so that the extremists who are our sharpest critics must subside because they begin to see the errors of their ways and understand them, not because they are browbeaten or outvoted.

It is an undeniable fact that teachers

must take what enters their doors in the fall and do what they can with the talents and characteristics that exist, however much that may be. They are dependent on these talents and characteristics and, however much, they can do no more than modify them and work with them. Some minds can learn some little arithmetic and presumably should, apt or not; others take to it easily and offer no problem in teaching arithmetic. Many parents and teachers know beyond a doubt that some children are strong spellers from the start, often coupling this with a bent for words and expression though not necessarily with a liking for literature and its connotations, whereas others, like a daughter of mine who at twenty-one spelled "tenure" appropriately as "ten-year," think more in pictures and ideas and less in terms of spelling and words as such. Specific points are dangerous. This is only an illustration, but to meet possible critics, I will say that this daughter knows that spelling is an essential grace which, with effort and attention, can be learned in moderation, but she will never be the speller her sister, a graduate in English, is, instinctively. How *much* can be done by will, against a passive acceptance of traits from outside the school room, is another problem.

This discussion is concerned with a consideration of criticism of education as such, with the application of the general rules of criticism to a nettling and vexatious problem of the day. However, the discussion goes necessarily so close to the roots of criticism itself that a closing note on that topic may be warranted. Calm acceptance of criticism, judicious appraisal of it, and a mature response to it seem to be the only ways properly to meet it, so long as we continue to try to improve our schools *not* to reduce criticism but without regard to criticism, seeking improvements that stand on their own virtues.

Specific criticisms, varied as they are, are a natural consequence of the true errors, the apparent errors, and the foibles of teachers themselves.

The *true* errors we must accept, yet they seem apparent in any school. Fewer of them are errors in education than are faults in the persons teaching or the persons taught, either of which can lead to criticism. A teacher's certificate, the need for a job, or a wish to teach will not make a teacher; and a student incompatible with most of his teachers, genius or not, is likely to be a seed of dissention sooner or later.

The *apparent* errors are those which look like errors but are not, and these have been the principle subjects of discussion. They do appear to be errors to the critics, else they would not lead to criticism. They must be analyzed and, when found not to be errors, explained by educational processes, not by pouting, by ignoring, by rejection, but by careful methodical education, with full knowledge that it will never be entirely successful.

The *foibles* of teachers play no small role in criticisms of education. Teachers catch butterflies. They are absent-minded, and some suspect feeble-minded. They live in ivory towers. When asked a simple question they beam with two-hour explanations which no one can understand. Say no, and they say yes and try to prove it, and *vice versa*. They are full of notions and opinions, or, sometimes, shy and diffident. They are naive. They are sometimes pompous, humorless, serious, or supercilious. They are experts in narrow fields but, paradoxically, regard themselves as therefore experts in many fields. They speak somehow weightily or jauntily, never normally. They often speak with a lecturer's slowness, beginning every simple idea with its ancient history and ending dully an hour later. Their geniality is forced. They boast of normal reactions and hobbies as though Congress should award medals for them. Altogether, they are quite vulnerable—rather a peculiar race! Critics from without see this, but often fail

to see that Sinclair Lewis did much the same sort of caricaturing with *their* trades and professions, and that any group acquires its earmarks. This is the answer. We have no reason to be proud of the little foibles we acquire or which come out with our profession, but we might as well laugh at them, and, when serious criticism is based on them, toss them back amiably with an indication that they are true, that they are accepted and not too proudly—and they are not one whit worse than the foibles of the other fellow, whoever he may be.

WHY IS THE NUMBER OF SCIENCE STUDENTS NOT INCREASING? *

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THE problem of recruiting science students is a particularly live one. It has gained the interest not only of many scientists, but industrialists and other business men as well. The numerous talks that are given and the number of articles that are published dealing with this subject, indicates the seriousness of the situation. Millions of dollars and many more millions of man hours are being spent in efforts to find a remedy. This paper will endeavor to mention some of the activities that are being undertaken, the results, and why the results are disappointing. The reasons for the failure to obtain the desired results, and a possible remedy for the condition will be included.

Probably the statement most frequently made is that the students' interest in the sciences, and particularly chemistry, as far as we are concerned, must be aroused. How this is being done is indicated in part by the following:

A. Science clubs have been for years and are being promoted in the various high schools. It is believed that there are more than 40,000 of these clubs organized in the schools over the country.

B. Student awards at all levels are being offered by various science departments and by many governmental and industrial organizations. Each week new reports appear that some company has allocated more thousands or millions of dollars for scholarships.

C. Many believe that increased counselling and planning will bring more students into the study of the sciences.

D. Abundant literature is being made available, containing information and propaganda for prospective students.

E. An extensive program of science fairs in the high schools over the country has been organized.

F. Some suggest that we stop scaring off students for one reason or another.

Commissioner Williard F. Libby of the A.E.C. has indicated (*Chemical and Engineering News Edition,* January 3, 1955) that "accomplishments of the giants of modern chemistry who have made our time the 'Golden Age of Chemistry' have intimidated students. It seems impossible to a student that he could add significantly to the body of knowledge developed by Enrico Fermi, Gilbert Lewis, and men of their calibre." And it has been said that the introductory courses to chemistry are much too theoretical to arouse the interest of most students.

All of the efforts and ideas may be very fine and no quarrel exists with them per se, but let's stop momentarily and see how the solution of the problem is developing. Reports are continually coming in that the number of science students is still on the decrease.

Last August there was held a two day statewide gathering called The Florida Science Fair Work Conference. Each session was attended by about 150 persons. They came from all over Florida. Special speak-

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ers were brought in from the Oakridge Institute of Nuclear Physics, the American Museum of Atomic Energy, from the District of Columbia, from Virginia, from Mississippi, and from Massachusetts—a truly impressive occasion. Think of the cost and time on just this brief conference. One speaker stated that the number of physics students during the past year had decreased 74 per cent; this after six years of science fairs.

Should not the continuing and alarming decrease in science students cause all to pause to re-examine the situation? Surely if our great minds and leaders would look upon this problem with the same critical attitude that they look up their laboratory and plant results, they would be bound to come to the conclusion that there is something wrong with the picture. It is contended that the return for the money and efforts spent is now and will be negligible in spite of the merits of the specific activities that are being undertaken. This means that the controlling factor in the situation is something quite apart from anything mentioned heretofore.

One may say, "Well, what about the shortage of science teachers and are they properly trained to do the job required?" This leads to the heart of the situation. Almost everyone says that there must be more and better teachers and various suggestions have been made as to how to accomplish this. It is a recognized fact that there are many teachers who are handling too many pupils in their classes. *Human Events,* of October, 1955, makes an interesting comment on this situation. It reports that the *Indianapolis Star* claimed that there was no shortage of teachers. This statement occurred in an item which commented on Federal Aid to Education. (By the way, the claim that Federal Aid to Education is of paramount necessity can easily be debunked.)

The report goes on to say that the accepted number of students per teacher per class ranges from 25 to 35. The U. S. Office of Education's figures say that in 1930 there were over nine hundred thousand teachers to more than 21 million pupils or one teacher to 24.2 students. In 1951 there were almost one million teachers to about 23 million pupils or a ratio of one to 23. But there are teachers who handle 40 to 50 students and there is a real shortage of teachers. What is the answer? *Human Events* indicates that there are too few teaching teachers and too many bossing teachers (supervising, counselling, advising, and administrating). From 1930 to 1951 classroom teachers increased 7 per cent while supervising personnel rose 85 per cent. It thus appears that the solution is to put more teachers back in the classroom. This building up of an organizational staff, as it were, ties into the purposes of the National Education Association which appear to be much more political than educational. Justification for this statement appeared in the September 9, 1955 issue of *Dan Smoot Speaks,* where it was stated that "During the week of July 8, 1955, 15,000 teachers, administrators, and other public school officials attended the ninety-third annual convention of the National Education Association in Chicago. There are many deeply disturbing problems which this group of professional educators might reasonably have been expected to consider. There is, for example, the problem of keeping America abreast of the rest of the world in the training of engineers and scientists to meet the needs of a technological age. The Soviet Union, Great Britain, Germany—possibly even Japan—are now surpassing us in this field of education. America's supply of future engineers and scientists is in danger of running out. If the supply does run out, America could, in this generation, become a fifth-rate power.

"America has the finest technical schools and colleges in the world. We have the greatest scientific research centers and the best laboratories on earth. We spend infinitely more on educating our young than

any other people in history. We have more resources, more facilities, more experience in the field of engineering and scientific research than the people of any other nation. How then could we be falling behind other nations in the training of scientists and engineers? The weakness is our public schools. Our public high schools are no longer giving adequate training in the fundamentals of mathematics, geometry, chemistry, and physics. These are all 'difficult' courses. In the relaxed environment of our public schools today, it is considered wrong to require anything difficult of students. That would be undemocratic. That would separate the bright ones from the dull ones, the energetic ones from the lazy ones. Hence, high school students are permitted to avoid the difficult subjects. They take electives, social studies, courses that are easy. The number of students enrolling in the public high schools increases enormously each year. Yet each year fewer and fewer students enroll for courses in algebra, geometry, mathematics, chemistry, and physics. The emphasis in America's fabulously expensive public school system is on mass production. The standards must be low, so that every youngster can enter. The requirements must be easy so that every one can pass. Nowadays, a high school diploma is nothing more than a certificate of attendance. This is one of the real problems of education in America. But such problems as this did not trouble the National Education Association at its convention in Chicago this year.

"The National Education Association is not interested in education. It is interested in politics.

"On July 4, 1955, at the N.E.A. convention in Chicago, Dr. Earl J. McGrath, now president of the University of Kansas City (formerly, 1949–1953, United States Commissioner of Education) outlined a program for organizing the nation's 1,250,000 public school teachers into one powerful political pressure group. Dr. McGrath, speaking to the Legislative Commission of the N.E.A., said that teachers should enter the political arena and exert maximum political pressure. He indicated that the teaching profession should be organized in such a fashion as to bring non-partisan political pressure on members of the Executive and Legislative branches of the Government to support measures calculated to improve the status and the condition of education in the state and federal governments. Dr. McGrath promised that if teachers would not be squeamish about slugging it out on the political front, they too, would get higher salaries.

"The nine-man Legislative Commission of the N.E.A. gave 100 per cent endorsement to Dr. McGrath's suggestions. The Commission pointed out that the State educational organizations had for some years been operating as pressure groups. From now on, however, the N.E.A. will operate as a powerful pressure group on a national basis, and the Commission promised that N.E.A. would not be fainthearted or squeamish in using political pressure.

"Mr. James L. McCaskill, Executive Secretary of the N.E.A.'s Legislative Commission, indicated that it is not enough simply to pass resolutions. We want to go beyond that. In each community, the teachers should ask their Congressmen: 'How do you stand on bill so and so?,' and on the answer, the teachers should know how to vote. We can't create constructive political pressure on paper. Before we move into a stronger position, we will need more teachers to work with us. We now have 612,000 teachers in the N.E.A. That is only 50 per cent of the teaching profession. When we get closer to 100 per cent, our voice will be heard in Washington more than it is now.

"As one of its first political pressure acts, the N.E.A.'s board of directors sent a telegram to Graham A. Barden, Chairman of the House Committee on Labor and Education, urging favorable action on a bill that would provide $1,600,000,000 of federal aid to the states for school build-

ings. But to the N.E.A. this is a bare beginning. The absolute minimum of Federal Aid to Education which would appease the N.E.A. was outlined at Chicago: $500,000,000 a year for school buildings; $300,000,000 a year for higher teachers' salaries; $200,000,000 a year in free tuition for high school students to go to college.

"The N.E.A. is almost certain to get what it wants. About a year ago Mrs. Oveta Culp Hobby, then Secretary of the Department of Health, Education and Welfare, laid plans for a White House Conference on Education to be held in November, 1955. This conference will, of course, be dominated by the National Education Association and by the National Citizens Commission for Public Schools, which works hand-in-glove with the N.E.A.

"The White House Conference to be held on the eve of an important election year and under the domination of two of the most powerful political pressure groups in the nation, will doubtless result in a mammoth federal aid to education program. The consequences of such a program, within a very few years, could be: (1) the destruction of all private schools; (2) the elimination of all local and state control of public schools; and (3) the complete nationalization of America's educational system.

"The people who agitate for Federal Aid to Education loudly deny that they have any such goals as these in mind. They hotly contend that no such consequences as these will result. They claim to be interested only in America's children. They point out the obvious facts that our schools are overcrowded and our teachers underpaid—and then they conclude that Federal Aid is the only solution.

"But where does the federal government get its money? From the people in the individual states. Why should the people of Florida pay money into the federal treasury in Washington in order to get a small portion of it back for helping to finance their local schools? And a small portion is all they ever get back, because a very heavy percentage of all the money you send into Washington has to be spent to maintain the frightfully expensive machinery of administration."

Probably the most commonly offered solution to obtain more and better teachers is to increase the salaries of teachers. This is exemplified by the statements by the President of the American Chemical Society, Dr. Joel H. Hildebrand, who is quoted in *Chemical and Engineering News* edition of September 26, 1955, as recommending that all of us speak out for higher salaries and, by the Secretary of the American Chemical Society, Dr. Alden H. Emery, who urges in the October 10, 1955 edition of *Chemical and Engineering News,* that increase in pay is a solution to the problem. However, there is another side to the higher salary argument as represented for example by the sentiments of Dr. Arthur Osol as quoted in the "Editor's Outlook" in the April 1955 issue of the *Journal of Chemical Education.* Dr. Osol said, "While agreeing that scientists, and especially teachers, generally receive inadequate financial remuneration for their services, I doubt very much that lack of financial reward is a basic reason for the shortage of teachers and scientists. It is unfortunate that there is a tendency in some quarters to hastily jump to this conclusion, and it is deplorable that there appears to be some trend toward evaluating all forms of human endeavor in terms of financial reward only. Such a basis of evaluation is not, and never can be, a common denominator for relating the merits of different professions, or of different areas of specialization within a profession, or of people themselves. I find it impossible to believe that the question of financial reward now motivates people so completely that little else matters when a job is to be selected."

The Editor of the journal, Dr. Norris W. Rakestraw, comments on Dr. Osol's statements by saying, "Teachers who are

attracted solely by salary are not likely to be effective or to remain long in the profession."

It is generally believed that teachers are the most highly underpaid group in the country today. However, under the present circumstances, the amount of money spent for education will not determine the standards of education. Do you believe for a moment that if the salary of all teachers were doubled that there would be a significant improvement in instruction?

Efforts to make better teachers of those who have entered the teaching career include various types of programs sponsored by the American Chemical Society at the local and national levels and in other ways. These are excellent endeavors and necessary if we are to approach anything like a complete solution to the problem, but under the existing unfavorable conditions, it is doubtful that they can be effective.

Much more important is the intial preparation received by prospective teachers and the educational philosophy with which they are indoctrinated concerning how and what the pupils in the schools shall be taught. It should be understood that the vast majority of our school teachers and officials are hard working patriotic citizens, who deserve more of everything good than they now receive. Contacts with teachers indicate that the vast majority of those in our school system would agree with what follows. Whether or not they will openly express that agreement will depend upon the circumstances. That may seem peculiar, but rest assured that only the teachers in the school systems who are not afraid of losing their jobs, speak out freely.

A few years ago General Omar Bradley is reported to have said that "if some dramatic incident could shock the American people into awareness of public education, they would react as unitedly as they did in Pearl Harbor." More recently Lt. General Leslie R. Groves said in *Industrial and Engineering News*, February 21, 1955, "Our education system has shown it is presently incapable of meeting the challenge which has arisen to confront it."

President Charles A. Thomas of the Monsanto Chemical Co. in an article entitled "Science Suffers from Anemia" which appeared in the *Chemical and Engineering News* edition of September 19, 1955, is quoted as saying, among other things, that, "There is an alarming tendency to choose the easy way out. The number of subjects in our high schools has mushroomed from nine in 1890 to 274 at present. Whatever the reason, our secondary schools have become a sort of educational cafeteria, offering a bewildering assortment of studies. There is no doubt that chemistry, physics, and algebra are more difficult than family relations or personal hygiene so why bother? Since they all lead to the same goal—the diploma —why not take the course of least resistance? That's the attitude many high school students have today. Most disturbing is the tragic waste of talent among the gifted students who succumb to the temptation to choose the softest subjects."

This attitude is nurtured in the favorable atmosphere of the modern school room. This new or modern education, the current alias for the progressive variety, has behind it a philosophy of the ancient Greeks. So it is neither new, modern nor progressive. The Greeks, who promoted this philosophy, were called "Sophists." Their sort of bamboozling was known for centuries as "Sophistry." Webster indicates that this term is a synonym for "deceptively subtle reasoning or argumentation." The great philosopher, Socrates, tried to expose those early day Progressives; you know what happened to him. A group, led by Anytus, which might have been called the "Helenic Citizens Commission for the Sophisticated Schools," framed old Socrates. And today the attacks by the so-called Progressives, on anyone who does expose the situation is violent and long-lived.

As long as the prevailing idea is to enter-

tain the children or to let them entertain themselves as they see fit (this latter, of course, coming under the heading of self-expression); as long as the poor student receives the same reward as the good student and as long as effort and work are treated as something to be avoided, the schools will fail utterly in their educational mission. This is not the fault of the individual classroom teacher. The latter are almost powerless to do anything about it.

Let me cite some statements confirming these ideas. Constance Row reported in an interview with William Owen in the *Saturday Evening Post,* June 23, 1945, in an article entitled "My Case Against Progressive Education," said, "Generally, however, the profession accepted several major theories as necessary to the cause; freeing the pupils from regulations and freedom of authority in the school room; elimination of the dread of failure in classes; adapting school curriculum to the mentality of the average student; grouping classes by age and social adjustments rather than by mental preparedness; permitting classes to advance at their own rate of progress." The results of these theories are very much in evidence in American schools today and the article goes on to say, "One of its most radical departures and, as it later developed, its most tragic weakness was a relinquishment of control in the school room. After the first few years, this weakness began to collide violently with some of the more common facts of life. Boys and girls who had delighted and awed us in the early grades, displaying ingenious capabilities for amusing themselves in the school room, were not so attractive when they began emerging as ten an twelve year olds exhibiting unmistakable evidences of total insubordination. The progressive theory provided no means of dealing with insubordination. Indeed the word has been eliminated from our vocabularies. Self-expression and complete freedom of the individual has been our aim." This situation was well illustrated in the moving picture "Blackboard Jungle" and if anyone thinks that this is a misrepresentation, all they need to do is follow the newspaper reports and the reports of J. Edgar Hoover on the tremendous increase of juvenile delinquency. In New York and other cities across the land, teacher's automobiles are damaged, neighboring stores are damaged, but the situation is so out of hand that neither the teacher nor the property owner dares make a report of the incident for fear of greater reprisals which frequently develop into personal attacks with knives and other weapons.

One of the favorite claims of the professional educator is that the students are being prepared for life (I don't know what kind of life they have in mind); self-reliance is being developed in the student so that they can meet world situations as they arise, but this self-reliance and resourcefulness is abandoned when it comes to the adult teacher. This is well illustrated by the proliferation of courses in so-called education which are supposed to train a teacher how to meet all the specific situations with which he may be faced. This indicates that the teacher is not sufficiently resourceful to meet the varying problems as they come up. Where is this self-reliance that the school child is supposed to obtain and which the adult teacher with far more training and experience apparently does not have?

The net result of the philosophy is that by and large the pupils are inadequately prepared in the basic tools such as reading and arithmetic, to say nothing about spelling, geography and history.

There is a decreasing number of students studying basic sciences primarily because the sciences such as Chemistry, Physics and Engineering, require rigorous training in Mathematics, English and similar courses. It takes mental and physical discipline to master these subjects and these are the very things students are not getting in the schools. Why not? Because the philosophy is that you musn't force a

student to do anything he doesn't want to do. It might be inhibiting the student's self-expression. Therefore, the student gets neither the course content nor the attitude required for the job. When many of these students enter college, they find themselves unprepared and so handicapped that they have no desire to undertake the task of majoring in a science. That is the crux of the situation.

What is the remedy? Some answers to this question have been proposed by Dr. Hildebrand. They are: (1) Speak out for higher salaries (here it is again), (2) Get elected to school boards (probably both difficult to do and useless under present circumstances), (3) See that the local section of the American Chemical Society has an effective program for chemical education (almost impossible), (4) Combat state requirements for teacher's certification that specify pedagogy at the expense of understanding the subject to be taught (this is an excellent idea, but to implement it is the problem), (5) Insist that the primary duty of schools does not end with the problems of children, but is to assist young people to become intelligent adults (one would think it should be unnecessary to say this). The parenthetical statements are not meant as criticisms, but are the true feelings of this speaker. The latter two suggestions come near the heart of the difficulty which is illustrated in part by the slogan of the school administrators, "We Teach Boys and Girls not Subjects." In some cases this objective is obtained by assigning teachers to subjects they never studied. What kind of results do you think come from such a philosophy as that?

In further illustrating the philosophy of those who determine the policies, permit me to relate to you the reaction of a high official of a college. He is a product of a college of education. When he was approached by one of his instructors with the idea of giving the same final examination to three different sections in the same course, the official commented as follows: 1. He never heard of giving "mass" examinations. (2) He indicated that it had been proved incontrovertibly that students make better grades if they take the final examination in the same room where they studied the course. Changing environment lowers grades. (I suspect that if the examinations were taken in a boiler shop the results would be somewhat affected). (3) Each section of a course should be taught differently, to meet the needs of each group, and therefore, each section should have a different examination. In particular, night students would be taught differently than day students.

Isn't the outlook for the future brilliant?

If one doubts that conditions are actually this bad, it is suggested that the many articles that are published in the current magazines and in book form on this subject be read. No real solution can come until the stranglehold of the professional pedagogues is removed. It is a national situation which may probably best be met through the State Legislatures. To obtain a solution, a number of individuals must be willing to spend a great deal of time in becoming familiar with what's really going on in the schools and know the arguments that will be presented by the professional educators. Then the job of selling the picture to the State Legislature, through their committees on education, must be undertaken. It is believed if one-tenth of the effort and money now being spent on obtaining science students and improving instruction in the sciences, were spent on exposing and correcting the basic source of trouble, the results obtained would be many, many fold greater. Under the present conditions, it is believed that money and efforts are almost completely wasted.

Everyone is aware that the public continually has its attention focused on the need for more classrooms, teachers, and money. Within certain limits these needs are real, but most assuredly the pedagogues are satisfied to keep the public occupied with these problems so that they will not know how poorly the educational process

is being conducted. Don't be fooled any longer. Read as much as you can on the subject and keep up on the critical current magazine articles. After some years of study, the picture will look quite different than the one painted by the professional pedagogues.

A SUGGESTED LIST OF BOOKS FOR READING

Smith, Mortimer. *And Madly Teach.* Chicago: Henry Regenery Company, 1949.

Smith, Mortimer. *The Diminished Mind.* Chicago: Henry Regenery Company, 1954.

Lynd, Alfred. *Quackery in the Public Schools.* Boston: Little, Brown Company, 1953.

Allen, Mary L. *Education or Indoctrination.* Caldwell, Idaho: Caxton Printers, 1953.

Bestor, Arthur E., Jr. *Educational Wastelands.* Urbana, Illinois: University of Illinois Press, 1953.

Chalmers, Gordon Keith. *The Republic and the Person.* Chicago: Henry Regenery Company, 1952.

Flesch, Rudolph. *Why Johnny Can't Read.* New York: Harper and Brothers, 1955.

THE POT CALLS THE KETTLE BLACK

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THE first decade of the last half of the Twentieth Century finds American Education bitterly assailed on one hand and vigorously, if not righteously, defended on the other. One has only to read such books as Lynd's *Quackery in the Public Schools,* Bestor's *Educational Wastelands,* Flesch's *Why Johnny Can't Read,* Smith's *And Madly Teach* and *The Diminished Mind,* Allen's *Education or Indoctrination,* Dunn's *Retreat from Learning,* and so on to realize the extent of the attack on present day education. Numerous articles in magazines and newspapers, as well as talks on radio and television give added support to the seriousness of these attacks. Numerous books, articles, and talks have presented the affirmative side to this sometimes bitter debate. Such books as Hechinger's *An Adventure in Education,* Woodring's *Let's Talk Sense About Our Schools,* Thayer's *The Attack upon American Secular Education,* Smith's *The Public Schools in Crisis,* Beck's *The Three R's Plus* and others, have attempted to objectively examine these criticisms, rather than pass them off as the utterances of those who have no actual basis for their complaints. Even Bestor makes proposals for improving public education in his *The Restoration of Learning.* Where does the truth lie? As is so often the case in controversies of this kind—probably somewhere between the concepts that *all is, in general, well with American Education,* and on the other hand that *something is radically wrong with American Education.*

If American Education is not doing as effective a job as it might, where lies the fault? Where there is so much smoke there must be some fire. As groups, many scientists and business men have become increasingly critical of American Education.

Probably every group must take some share of the responsibility for the shortcomings of education. Teachers and educators are aware, often painfully aware, of the weaknesses and failures of American Education. We college teachers know only too well the deplorable weaknesses that many college students bring to our classes —little knowledge of mathematics, even arithmetic, often only a smattering of science, surprising ignorance of history and English, inability to spell and write legibly or readably, and so on. Whose fault? Nearly everybody's. The scientists, industrial leaders, and business men who are now raising questions as to the inadequacies in science and mathematics both as to number of persons trained and the quality of training are rather late in awakening to the present crisis. Where have they been in the past? Where are most of them now? They are all too often perfectly willing to let the other fellow do it if it means in-

creases in taxes and/or actual financial assistance.

For too many years college teachers of science have glibly, deliberately ignored teaching in public schools as of no concern to them personally or as a group. They have looked down their noses with scorn at their colleagues in the departments and schools of education. Steeped in the philosophy that teachers are born not made, they have sneered at the efforts of colleges of education to upgrade pre-college teaching. Many believe and vocally, even vigorously, assert that too many hours in education are required for teacher certification. They would be the first to deny that doctors or engineers are born, not made. Seemingly elementary and secondary level teachers are the only ones to whom this unusual distinction applies! If they would only examine the quality of teaching in their own departments, they would be forced to the conclusion that there are some Ph.D.'s who are not born teachers. Actually some of the poorest teaching at any level is done by Ph.D.'s. Having a Ph.D. is by no means a guarantee of good teaching. As a general rule, it is probably true that teaching gets progressively worse from the first grade to the graduate courses. Many teachers of graduate courses would not last very long teaching in the grades. The writer emphatically believes that a teacher should know what he is attempting to teach. A teacher cannot teach others that which he himself does not know. A prime requisite of the secondary science teacher —even the grade school science teacher— is to really know and understand what he is teaching. One cannot really teach high school chemistry students to solve chemical problems and balance equations unless he can do so himself. One cannot teach understandingly about the cause, times, and kinds of tides unless he has a fairly good understanding of Newton's laws. Surely accurate knowledge should be a prime prerequisite for a science teacher at any level.

It is quite likely that a very important reason why more teachers and college students do not take more science courses than they do is because of the poor quality of teaching in those very science courses! Could be! Thus it is undoubtedly true that college science teachers are themselves to blame for much of the present dire situation in science. It is even a suspect that college science teachers have not learned this fact even in 1957. Who taught these elementary and secondary teachers the little, inaccurate science they do have? Why these very same highly superior college science teachers who were born, not made! Who, because they were born teachers and know so much science ought to find teaching science to elementary and secondary-school teachers an unusually simple and easy task!

These same college science teachers proclaim, and rightly so, the values of research in all phases of pure science, yet they still blandly ignore and are, to a large degree, ignorant of the results of science teaching research carried out by their colleagues in schools of education. This is evident even in a January, 1957, article in a noted educational publication.

The present awakening by various science organizations, groups, and foundations to the seriousness of the present science situation is late, but highly commendable. There is a tendency to think that only the pure scientist or college science professor is qualified to do the job. This could result in much disappointment and in a generally botched-up job—especially since a great deal of the effort ignores what has been done in the past and is spasmodically planned and carried out. There may also be much undesirable overlapping and a thinness in some instances that will prove most frustrating and barren of desirable tangible end-results. Lack of an adequate understanding of present-day psychology, desirable class-room procedures, methods of evaluation, and ignorance of what science education research has already found out could in the end defeat, to a large extent, the noble goals now envisioned.

Professional school personnel, public

school administrators and Deans of Schools of Education can likewise take a large share of the blame for the present science and mathematics situations. Per se they have been too little interested in either science or mathematics. The reasons are many and varied, but some major ones are not hard to find. As a group, they themselves know little science or mathematics. They had or learned little science or mathematics in secondary school or college. In one state it is said that 65 percent of all school administrators, superintendents, and junior and senior high school principals are physical education majors or former college athletes. It is admittedly true that this group has never been known for their accomplishments in mathematics or science. They have a feeling that they are doing pretty well, even unusually well, in their jobs as school administrators, so why all of the hullaballou about science and mathematics. It is expensive to provide adequate facilities for teaching science and to find adequately trained teaching personnel in science and mathematics. It brings much more notoriety to build a colossal gym or football field than to build or equip a science laboratory. So anyone and everyone who has the nerve or the brass, regardless of training, is assigned to teaching science and even mathematics in secondary and junior high schools if they will accept the assignment. Most of the administrators seem to believe or are firmly convinced that anyone who can read a general science textbook can teach general science. As a matter of fact, general science actually requires a better trained person to teach it, than do such subjects as biology, physics, and chemistry. However it is easier to "get away with" or "get by with" poorly trained teachers in general science than it is in chemistry or physics. Such an attitude or belief will not, and cannot develop an adequate science and mathematics program in pre-college education. The greatest need in public education is adequate, professionally trained leadership.

The writer has somewhat recovered from an experience of some years ago with the personnel director of a certain school system. A remark was made to the effect that the primary purpose of education in the lower grades was to teach pupils to read, write, spell and do arithmetic as effectively as pupils' individual talents permitted. We still believe every pupil in the elementary grades should achieve these skills. Not so said this personnel director. This person vigorously maintained that the main purpose of the elementary schools is to make pupils happy. If pupils were always happy, then the schools have achieved success regardless of any skills in doing reading, writing, spelling, and arithemetic. These skills were mere by-products in the educational mill. With a philosophy that the main function of public schools is to make pupils happy, the need for more qualified teachers, improved equipment, and more school room space would seem to be obsolescent. What would seem to be really needed is a Pressley, a Davy Crockett, a cowboy, a wild-west badman, more Mickey Mouse and blood-and-thunder movies, an increased supply of comics, and more crime inspired, liquor-drinking juvenile material on television. Most juveniles of all age levels could then be really happy! And to continue happily on into adult life, there is needed primarily plenty of super-speed cars and an adequate supply of spirits to take into a happier make-believe land. The writer is neither denying or affirming that some of the above do not have their place. We do believe very emphatically there is a place for reading, spelling, writing, arithmetic—even science in the elementary grades! The writer is not even remotely against pupils or anyone else being happy, but it did not seem to occur to this personnel director that pupils might even be happier if they had developed these skills than if they had not. Teachers well trained in mathematics, science, and English probably receive only lip preference in this school system when the major prerequisite is whether or not they can make pupils (and

parents) happy. The most important question asked a prospective teacher in this system would seem to be Can you make pupils and parents happy?

And at the college level too many Deans of Education take an altogether nonchalant attitude toward having persons on their staff professionally trained to offer adequate courses in the teaching of science, directing science education research, or supervising student teachers in science. The situation along this line has grown even worse than it was a decade ago. Seemingly as the importance of science in everyday living in this Atomic Age has loomed ever larger, the percentage of professionally trained science education leaders has decreased. We could name college after college which has no trained person or persons for any level of science education leadership. Or we could ask who took the place of so and so when he left or retired? You name the college. That has happened all too frequently. Is it any wonder such an attitude has permeated down to the public school levels? This attitude is reflected also in the quality of research going on at the graduate level. Even the amount, let alone the quality, of research in science teaching has declined seriously in the last decade. There is no reason to assume that the same generalization does not apply to the teaching areas of English, mathematics, history, social studies, and so on. As for the individual teacher himself, he naturally asks the question, Why do research in science or mathematics if no recognition—financial or professional—is given the recipient?

Too many doctoral theses are being written by ghost writers. Such writers have their places, but that place is not a doctoral thesis level. If one requirement (and why shouldn't it be?) is that the individual write his own thesis, the number of doctor's degrees granted might be considerably lessened but would result in the long run in the upgrading of doctoral research. Why not tell a doctoral candidate that he cannot get a degree unless he writes his own thesis. Let's abolish the practice of having someone else write the candidate's thesis and/or even furnishing the material itself. No wonder some holders of the doctor's degree or would-be holders say getting a doctor's degree is an expensive proposition! Surely better checkups can be had in our graduate schools, but it will need a person trained in the area himself (e.g. science education) to see that this job is done adequately. We do not mean to imply that such conditions as the above are typical or general. Definitely they are not. But they could and should be reduced to zero.

We in science education are not by any means blameless. Too often we have not been as professionally minded as we should have been. We have not done the thinking, the reading, exerted the leadership, publicized our research and studies as we should have, set up desirable standards for teacher certification in science, voiced our objections to permitting deplorably unprepared teachers to teach science, and so on. In a large measure schools of education have failed to develop professionally minded teaching personnel.

Is the situation hopeless? By no means. All the criticisms leveled at education and science education should be carefully analyzed and studies made that will result in at least tentative solutions. We in science education can and should work more understandingly and effectively with school administrators, deans of education, business men, scientists, and industrial leaders. There could be a Golden Age of science in the public schools and colleges just around the corner. But complacency will not bring it about. We are too prone to magnify the mote in the other person's eye so that we are unaware of the beam in our own eye. The time is at hand for both the pot and the kettle to become shining bright! Both have been black long enough.

BOOK REVIEWS

RICKETT, H. W. (Editor), WALCOTT, MARY VAUX AND PLATT, DOROTHY FALCON. *Wild Flowers of America.* New York (419 Fourth Avenue): Crown Publishers, Inc. Unpaged. $10.00.

Here are 400 color plates of 400 wild flowers of North America shown in actual size in beautiful true-to-life color, with detailed descriptions, and with full information as to family, geographical range, nature of environment, and so on. Common names and their variations as well as standard botanical classification and nomenclature are given for all flowers. Chart lists the flowers by distinctive features and facilitate identification. There is a detailed glossary.

This encyclopedic work is based on an authoritative publication of the Smithsonian Institution: The Mary Vaux Walcott color plates in this book are reproduced by permission from the famous portfolio set "North American Wild Flowers" by Mary Vaux Walcott as published by the Smithsonian Institution. The magnificent and completely accurate paintings, which are accorded top ranking by artists as well as botanists throughout the country, have been supplemented by additional paintings by Dorothy Falcon Platt.

If you love flowers and beautiful paintings of flowers, then here is probably the finest book on flowers you will find anywhere. It is truly a picturesque book. It is an excellent reference book for any school library or science book shelf—elementary, junior high, or secondary and for teachers at these levels as well. It is a fine book to just look at and enjoy!

MANNERING, EVA. *Fruits and Flowers.* New York (419 Fourth Avenue): Crown Publishers, Inc. 1956.

Fruits and Flowers consists of twenty-four color plates selected from "Choix des Plus Belles Fleurs et es Plus Beaux Fruits" by Pierre-Joseph Redonte, first published in 1827. Redonte has been acclaimed the most famous botanical artist of all time. This the reviewer can well believe. Words cannot adequately describe the beauty of the twenty-four plates in this book.

There is brief descriptive matter near the front of the book for each of the fruits and flowers depicted in the twenty-four plates. Each plate properly framed would make an unusually beautiful picture. Here is truly fruit and flower superbly painted.

Common names of the fruits and flowers in the twenty-four plates: Apple, Passion Flower, Pansies, Redcurrent, Harebell, Apricot, Camellias and Narcissi and Pansies, Garden Plum, Tulip, White Grapes, Amaryllis, Primula, Red Camellia, Filbert, Nasturtium, Pomegranate, Gentian, Cherry, White Camellia, Peach, Blanket Flower, Dahlia, Strawberry, and Carnation.

MANNERING, EVA. *Mr. Gould's Tropical Birds.* New York (419 Fourth Avenue): Crown Publishers, 1956. $7.50.

This book consists of twenty-four plates selected from John Gould's Folios together with description of the birds taken from his original text. At his death in 1881 Gould had published some 2999 paintings of birds, the combined work of himself, his wife, Edward Lear, H. C. Richter, and W. Hart. It is said that there have been other artists of ornithology whose individual paintings have equalled and surpassed those published in the Gould Folios but none has bequeathed a contribution remotely approaching in stature and comprehensiveness the life work of Gould.

Brief descriptions of each bird painted is found at the front of the book. As in *Fruits and Flowers* each painting could most appropriately be framed for a beautiful painting.

Birds portrayed are: Grey-breasted Aracari, Collared Trogon, Cuba Trogon, Giant Trogon, Mexican Trogon, Doubtful Trogon, Pennant's Parrakeet, Yellow-rumped Parrakeet, Earl of Derby Parrakeet, Beautiful Parrakeet, Ewing's Fruit Pigeon, Peaceful Dove, Rustic Bunting, Sepoy Finch, Himalyan Pteruthius, Red-headed Bunting, Nepal Martin, Veraguan Lance-Bill, Ecuador Racket-Tail, Purple-Tailed Comet, Buff-breasted Leucippus, Piedtail, and Mrs. Gould's Sun-Bird.

FEININGER, ANDREAS. *Changing America.* New York (419 Fourth Avenue): Crown Publishers, Inc. 1955. 170 P. $5.95.

Changing America is truly a beautiful book with 158 pages of photos by one of the world's greatest photographers — remembered for his earlier *The Face of New York, Feininger on Photography, New York, Successful Color Photography,* and so on. The pictures are superb and there is brief text by Patricia Dyett. Some ten pages in the rear presents the facts behind the pictures.

Nearly every phase of American activity and Natural America is depicted. One is thrilled at looking at the pictures and realizing the true significance of what makes America great. The photos encompass America from its raw beginnings to its highly industrialized present.

This book is a grand book for anyone to have—almost of any age level. It is highly recommended for the grade school, junior high school science book shelf, or school library. It would be difficult to produce a finer book of the American scene and show why America has become the leading nation of the world.

Naturally the industrial applications of science receive major attention in the book—farming, coal, oil, iron, construction, and so on.

KAHN, FRITZ. *Design of the Universe: The Heavens and the Earth.* New York (419 Fourth Avenue): Crown Publishers, Inc., 1954. 373 P. $5.00.

The blurb states "This is a book in the tradition of the great popularizations of human knowledge such as Wells' *Outlines of History,* Durant's *Story of Philosophy,* and Hogben's *Mathematics for the Millions. Design of the Universe* is the story of the universe around us, what it is like, how it came to be, the earth's place in the universe, and man's place on earth. The coverage is comprehensive and written in language the layman can understand.

Part One considers the *World of Modern Physics*—space, time, matter, and energy in classical and modern physics. Part Two considers the atom. Part Three discusses the Heavens—the instruments and methods of modern astronomy, the galaxy, the universe, the stars, the planetary system, the earth and moon. Part Four tells about the Earth—structure, the stony book of the earth's history, floating continents, air, water, and land. There are 150 illustrations. This is indeed an outstanding book, recommended to high school science teachers, elementary teachers, and all persons interested in securing an understanding, more appreciative insight into this universe in which man has been alloted so short a span individually.

AUSUBEL, NATHAN. *Pictorial History of the Jewish People.* New York (419 Fourth Avenue): Crown Publishers, Inc. 346 P. $5.00.

Pictorial History of the Jewish People is a history of the Jewish people from Biblical times to our own day throughout the world. It is truly encyclopedic, clearly presenting the exciting events of Jewish history, the essence of Jewish ideas, and the names and facts about notable Jews of all ages, from all countries of the world.

These pages also constitute the largest and most important collection of related pictures ever printed in one volume—some 1200 in all—selected from more than 10,000 assembled from private and public sources everywhere. Every aspect of Jewish life is covered—religious and secular.

A lifetime of study and research went into the preparation of the text and commentaries. The author consulted works and documents in Hebrew, German, Yiddish, and English.

This is a book for young and old. Talmudic scholars will admire and respect it. Those who know little about Jewish tradition will find it a rich storehouse.

First the author discusses who are the Jews and the Land of Israel. Then follows some ninety pages of early Jewish history from the first Hebrews until Israel was dispersed among the nations. This rather closely parallels the Old Testament. Some fifty pages follow on the history of the Jewish people in the medieval period. The last two hundred pages presents the history of the Jews in the modern people—country by country.

This book is an outstanding contribution to be prized by both Jew and non-Jew. It is an unusually fine reference and resource book.

The Autobiography of Jesus. Boston: Bruce Humphries, Inc. 1955. 31 P.

This pamphlet presents the life of Jesus as if Jesus Himself were writing His own biography. It presents Jesus from a unique and challenging point of view. In a way it makes Him a more real, live person—at least it will so seem to many individuals. Many individuals will want a copy!

GAMMANS, HAROLD. *Lincoln Names and Epithets.* Boston: Bruce Humphries, Inc. 1955. 38 P.

This compilation is based on an examination of several hundred thousand books, broadsides, pieces of sheet music, pamphlets, newspapers, manuscripts, cards, micro-films, etc., found in libraries and private collections.

More names and expressions of exaltation and condemnation have been applied to Lincoln than any other human of the Christian era.

Names and epithets—some 780 in all—are listed alphabetically and credited to one source in all cases. Undoubtedly Lincoln has been called more exalted names as well as more hated, derogatory names than any man in human history. And the author admits his list is probably far from complete!

Continued from Front Inside Cover